

Prioritizing Land for Conservation in Northeast North Carolina

by

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ABSTRACT

The northeastern coastal plain of North Carolina provides a number of irreplaceable values like habitat for wildlife, economic gain through tourism, and social value through recreation and aesthetics. New development in this region may alter existing undeveloped lands that are important to wildlife and the community. In order to preserve lands in the face of this threat, land trusts like the North Carolina Coastal Land Trust (NCCLT) work to protect lands from development in perpetuity. Due to limited funds and resources, land trusts must ensure projects they undertake are both within the mission of the organization and of high conservation value. Site prioritization schemes are a way to aid the decision making process when undergoing conservation projects.

In coordination with the North Carolina Coastal Land Trust, this study uses a multi-criteria decision analysis and GIS site prioritization to identify parcels of high conservation value in 5 priority regions within North Carolina's northeastern coastal plain. Parcel level prioritization analyses were performed in ArcGIS using a utility analysis and value-based framework to determine parcels of highest conservation significance. Criteria included in this framework were based on acreage, connectivity with other managed lands, biodiversity, threat of development, and riparian frontage. As part of this process, a GIS Land Prioritization tool was developed that (1) provides summary statistics of important conservation criteria for each parcel across any region of land; (2) allows for manipulation of the actual prioritization method, weighting of values, and point scheme so the land trust can prioritize certain criteria differently in future analyses; and (3) outputs a list of parcels and their associated conservation scores for each parcel depending on the point scheme and weights defined by the user. While the tool allows for any number of point schemes to be used, the analysis performed here uses an equal weighting method across criteria. Results indicate a range of conservation values for parcels in each priority region. The findings from this study and the GIS tool created can be used both proactively and reactively in conservation planning efforts and project decision making in North Carolina.

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INTRODUCTION

The northeastern coastal plain of North Carolina is rich in wildlife sanctuaries, farmland, and riparian frontage, and provides a number of ecological, social, and economic values to the state and its residents. Land is abundant and sparsely populated. However, like many places across the country, new development sprawl from urban areas is still a potential threat to existing undeveloped lands. Land trusts like the North Carolina Coastal Land Trust (NCCLT) work to protect lands from development in perpetuity. Of the 26 land trusts currently working in the state of North Carolina, the NCCLT is the only regional trust working in the coastal plain of the state. NCCLT protects land through fee simple acquisition, conservation easement, and transfer and has protected 61,000 acres since it became established in 1992. The organization protects a wide range of habitats from pristine beaches to working farms and forests. While the NCCLT works in 34 counties along the coastal plain, this report only focuses on the 14 counties in their northeast region (Figure 1).

NCCLT is not alone in its land conservation efforts. Over 1700 land trusts exist nationally with over 47 million acres conserved as of 2010 (LTA 2011). Land trusts generally protect land through

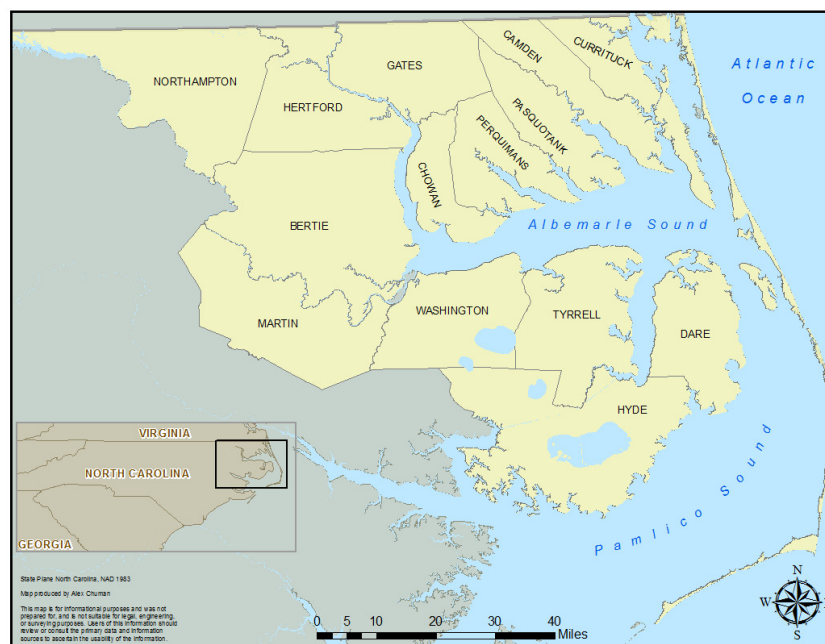


Figure 1: Northeast Region of North Carolina's Coastal Plain. The NCCLT works in 34 counties along the coastal plain, but this report only focuses on 14 counties in the northeast region.

acquiring properties in fee, working with landowners to place conservation easements or restrictions on their property, and/or assisting municipalities or townships acquire property for conservation or recreational use. Mission statements of land trusts may vary. For example, some may emphasize water quality, and some may focus on public access and recreation on their properties, but generally the overarching goal of a land trust is to protect land from development in perpetuity.

The pace of private land conservation has increased dramatically in recent times, with 23 million of the 47 million acres conserved in the U.S. occurring over the last 10 years. Of all the land trusts in the country, 83% have selection criteria for potential conservation projects and 70% have strategic plans that identify priority areas in their region (LTA 2011). The way land trusts prioritize lands as part of these strategic plans varies. Generally, there are four approaches to select conservation criteria in prioritization projects (Amundsen III 2011). Each of these approaches has their own strengths and weaknesses, and this report uses aspects of the following 4 approaches at different stages.

(1) Qualitative Criteria: This approach relies on the expert opinion of the staff or board in making decisions. While this method can be effective if staff is well versed and considers the right questions, it is less transparent and can overlook desirable or undesirable attributes unknown to decision makers without more scrupulous analysis.

(2) Threshold or screen based criteria: This approach screens out any projects that do not adhere to a certain standard. For example, all parcels under a certain acreage are waived and not considered. This tactic is often used by land trusts which deem small acreage parcels are not worth the significant time involved in acquisition, monitoring, and stewardship. Thresholding may save time in removing certain parcels, but it has the potential to miss extremely valuable parcels that may not meet a given area threshold. For example, a parcel that is removed due to small acreage may be a valuable habitat patch for an endangered species, but would be removed from the analysis and lost under the thresholding approach.

(3) Quantitative Value based Criteria: This approach assigns values to certain criteria deemed valuable to the land trust or conservation organization. Values are then summed to determine which parcels score the highest and lowest. This method considers different criteria equally even if the conservation organization values one criterion over the other. For example, all parcels over 100 acres may receive 1 point, and all parcels adjacent to a riparian area may receive 1 point. A 100 acre with riparian frontage would therefore score 2 total points.

(4) Weighted Scoring: A variation of (3), this approach assigns values but weights criteria according to what the land trust considers most valuable. For example, riparian frontage may be weighted to be the most important criteria and worth more points than all other criteria. While value based, approaches (3) and (4) still depend on user defined inputs that can introduce bias into the rankings.

The study presented in this report uses multi-criteria decision analysis (MCDA) to determine parcels of high conservation value in the region. Multi-criteria decision analysis is a “collection of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter” (Belton and Stewart 2002, pg 2). MCDA presents a transparent way for organizations to make structured decisions that involve a variety of conflicting criteria. In this process, the decision makers in an organization establish an objectives framework where an overarching goal is measured by a set of criteria. In this case, a number of criteria considered valuable to conservation are used to distinguish conservation value between lands according to the primary goals of the organization. Within each of these criteria, specific indicators exist that measure the criteria. While a number of MCDA frameworks exist, this study uses a multi-attribute utility analysis and a GIS value based prioritization method similar to approach (4) listed above.

Geospatial analysis (GIS) has often been used to prioritize lands across a variety of environmental fields, from selection of sites for renewable energy (van Haren and Fthenakis 2011), to prioritizing specific habitat across landscapes (Meinke et al. 2009). Site prioritizations coupled with criteria analysis are often performed for conservation in ecology and land management (Lathrop Jr and Bognar 1998, Kazmierski et al. 2004, Machado et al. 2006). These prioritizations are run across a range of scales, from larger landscapes or ecoregions (Strager and Rosenberger 2007) to parcel size scales (Gorokhovich and Voustianiouk 2010, Hozmueller et al. 2011). For example, a number of studies have prioritized specific watersheds for different conservation goals through geospatial analysis (Jain and Das 2010, Peacock et al. 2012). Smaller scale studies have also used GIS models to prioritize sites for wetland restoration (Kauffman-Axelrod and Steinberg 2010, Flanagan and Richardson 2010, Strager et al. 2011). Similarly, Li and Nigh (2011) utilized geospatial analysis to prioritize species richness in parcels. In many of these models, a set of criteria is developed, weighted, and applied to individual land parcels or regions and given a score based on the number of criteria satisfied. The parcels with the highest score are presumably the lands that should have the highest priority for conservation efforts. While not represented in scientific publications, many land trusts like the NCCLT have previously used or recently begun to use GIS prioritization analyses to map out priority regions of high significance. Site prioritization schemes through GIS or MCDA provide a way to aid the decision making process when undergoing conservation projects.

NCCLT has used point based site prioritizations in different regions in the past for strategic planning purposes, including in multiple locations in their northeast region. Such conservation plans are useful and can be developed more specifically to each region compared to the more general method applied here, but they require a substantial time commitment for staff or students. The Land Prioritization tool accompanying this report will allow the land trust to more efficiently perform site

prioritizations if they add or wish to update conservation plans of priority regions within the coastal plain.

Study Area:

The 14 counties that represent the area of northeastern North Carolina in this study cover over 3.4 million acres and have a vast range of forested and wetland habitats, coastal areas, and aquatic systems. The region is characterized by extensive riparian and coastal frontage along the Albemarle, Pamlico, and Currituck Sounds. Major rivers in the northeastern coastal plain include the Chowan, Perquimans, Little, Pasquotank, and North Rivers, which all run on the same axis from northwest to southeast into Albemarle Sound. The Roanoke River and Alligator River are also major rivers flowing into the Albemarle and Currituck Sounds. The watersheds associated with this part of the state include the Pasquotank River Basin, Chowan River Basin, Tar-Pamlico River Basin, and Roanoke River Basin. The elevation of the northeast region is lower than most of the rest of the state, with much of the Albemarle Peninsula below or at sea level.

The major industry in this region is agriculture, and farmland is the most extensive land cover. Notable towns and cities include Elizabeth City, Edenton, Williamston, and Plymouth, but much of the land is sparsely developed. The estimated population of the 14 counties is just 263,605 people over the 3.4 million acres (OSBM 2014). While other areas in NC such as the Research Triangle, Triad, and greater Wilmington area are experiencing the greatest population booms in the state, threat of development sprawl still exists surrounding major population centers like Elizabeth City and the southern Virginia metropolitan areas of Norfolk and Virginia Beach. The counties bordering the Norfolk area (Currituck, Pasquotank) have experienced greater than 20% population gain from 2000 to 2010 (OSBM 2014). Other counties of significant growth during this time period include Camden, Gates, and Perquimans.

This region of the state has numerous Significant Natural Heritage Areas (SNHAs), National Wildlife Refuges (NWR), and state managed game lands and parks (Figure 2). The Albemarle Peninsula in

particular is dominated by managed lands including large refuges like Alligator River NWR, Lake Mattamuskeet NWR, and Pocosin Lakes NWR. Other notable large tracts of protected lands include the Dismal Swamp NWR and State Park on the Virginia border, Roanoke River NWR, and the Chowan Swamp Game Lands. Of the approximately 3.4 million acres in the study region's boundary, over 1.1 million acres of land are managed for different degrees of conservation by non-profits and federal, state, and local governments.

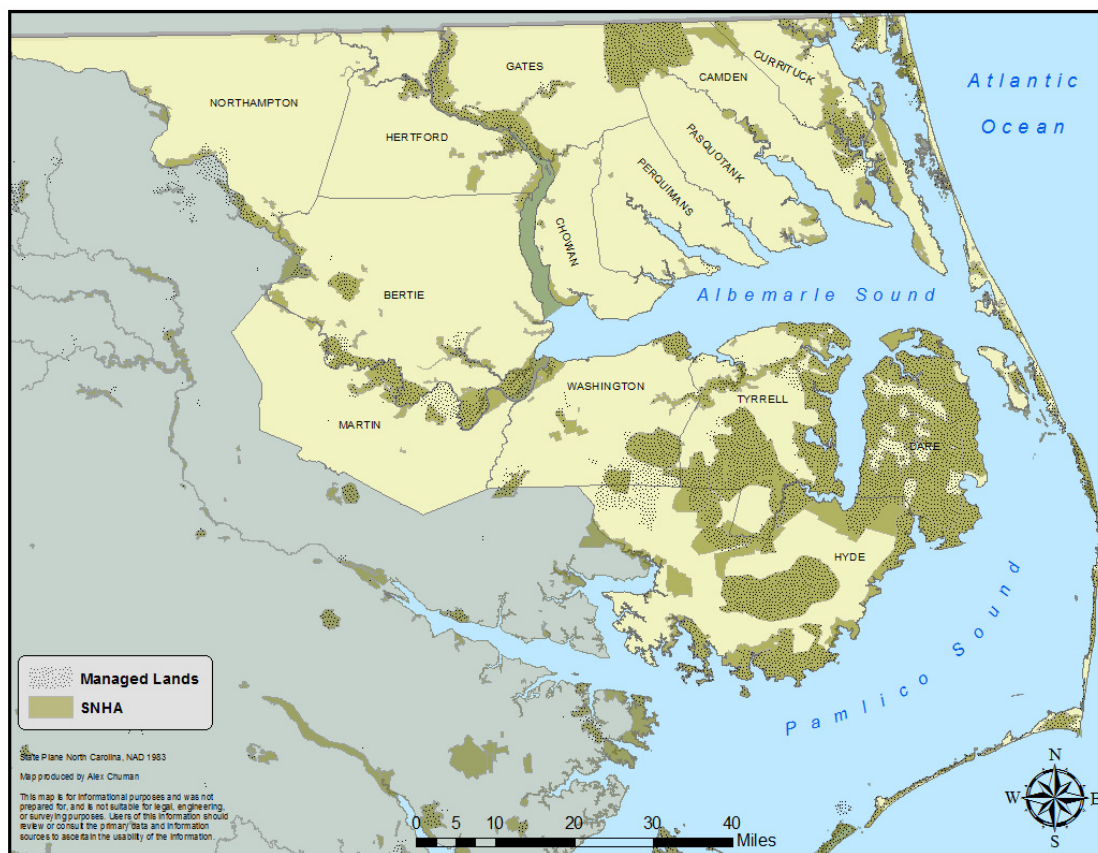


Figure 2: Managed lands and Significant Natural Heritage Areas (SNHAs) in the northeast coastal plain

Climate change and associated sea level rise are a major threat to the lands in this region. Annual average temperature in the Southeast United States has risen 1.6 degrees F since 1970 and could increase anywhere from 4.5 to 9 degrees F over the next century according to the IPCC (NCRC 2010). Furthermore, the N.C. Coastal Resource Commission's Science Panel on Coastal Hazards recommends

North Carolina plan for a 3 foot (1 meter) increase in sea level by 2100. Associated sea level rise will push coastal species and humans inland, potentially causing increased human-wildlife conflict. Many wildlife species will likely be affected, including migrating shorebirds, endangered sea turtles, and the critically endangered Red Wolf (DeWan et al. 2010). Sea level rise will also likely affect coastal landowners and property values of highly vulnerable lands. Compared to the rest of the state, northeast North Carolina is likely due to experience higher rates of sea level rise because of its geology and low elevation. In fact, much of the Albemarle Peninsula is already below sea level (Figure 3).

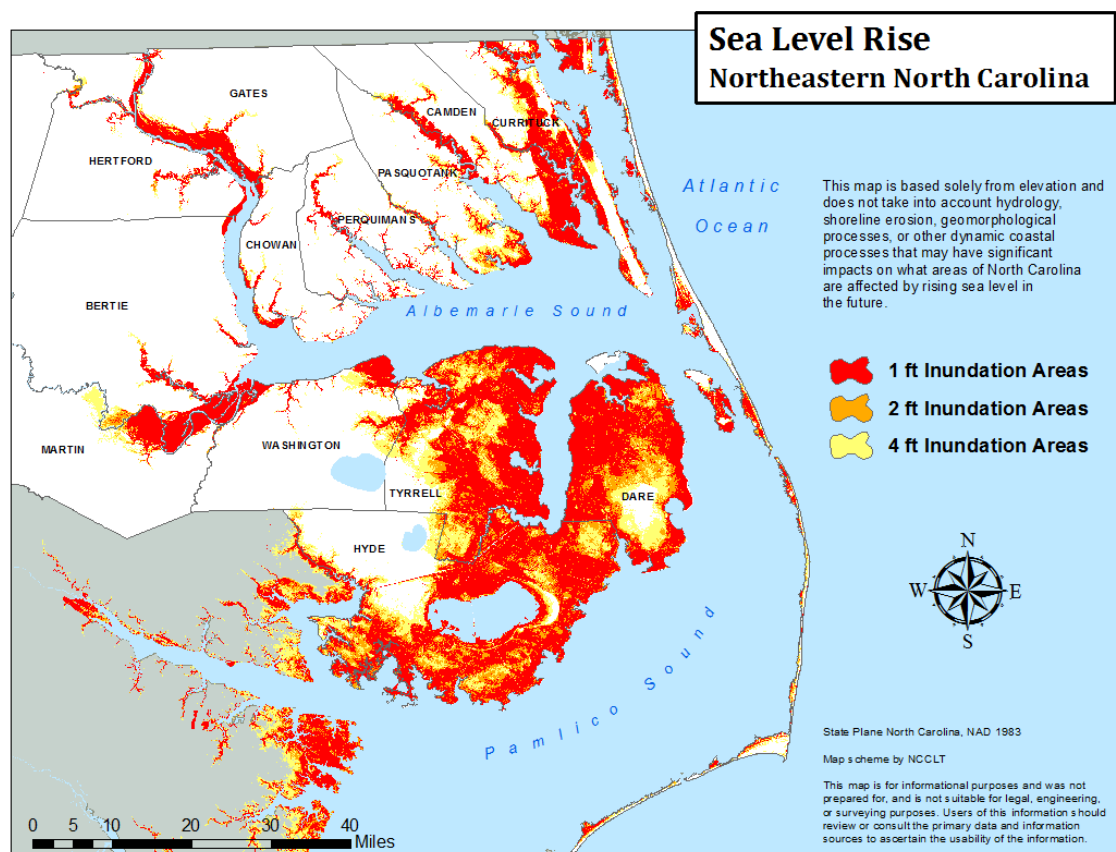


Figure 3: Sea level rise across 3 inundation scenarios. Much of the Albemarle Peninsula is below sea level. This map is based solely on elevation and therefore does not account for many factors that will affect where and how areas are inundated.

Subdivisions stretching over large tracts of land are the major land development threat in the northeast region of the state. As noted, areas of significant development threat from sprawl include the greater Elizabeth City area and parts of the state within commuting distance to the Norfolk and Virginia

Beach areas. Along with destruction of habitat, development of lands may also reduce water quality through increased run-off or wetland filling. Beyond climate change, sea level rise, and development, other environmental concerns in the region include fire suppression, invasive species, and water quality issues.

Objectives:

This study aims to answer which regions, and parcels within these regions, in North Carolina's northeast coastal plain have the highest conservation value, and how these parcels should be prioritized for future conservation efforts. To answer this question, this study seeks to:

- 1.** Identify smaller priority regions as focus areas within the northeastern coastal plain.
- 2.** Establish criteria and indicators that will be used to determine conservation value of parcels within these focus areas.
- 3.** Use a multi-attribute utility analysis to develop utility values and weights for each indicator and criterion in each priority region. Use this analysis to determine conservation values of parcels in each region.
- 4.** Design an ArcGIS tool that allows the user to define both utility values and weights in future prioritization analyses. The tool will automate the entire prioritization process and allow similar analyses to be run quickly according to the overall objective in each existing or future priority region.

The final product of this study is a user friendly method to perform site prioritization in the form of a GIS tool. The inputs to this tool are transparent and replicable. In the long term, NCCLT can use this tool to determine parcels of high conservation values, and weight the attributes deemed most valuable accordingly. In the short term, this study indicates possible parcels of high conservation value in multiple priority areas across the northeastern coastal plain. The results of this study and the GIS tool

could be used either proactively by NCCLT in contacting landowners with high ranking parcels, or reactively as a reference when the land trust is approached by interested landowners.

METHODS

Priority Region Selection:

Due to the extensive size of the region, the initial step in this study was to identify a subset of priority regions. After discussion with NCCLT, 10 priority regions were selected based on their proximity to existing NCCLT lands and managed lands, approximation of ecologic value assessed from the Biodiversity Wildlife Habitat Assessment tool (NCNHP NCPT 2013), lack of coverage from other conservation organizations, and riparian significance. For this study, five of these regions were chosen for parcel level analysis. These regions are Ocracoke Island, Edenton-Highway 32 Corridor, Pasquotank River, Pasquotank County Farmland, and Currituck County Farm and Forestlands (Figure 4).

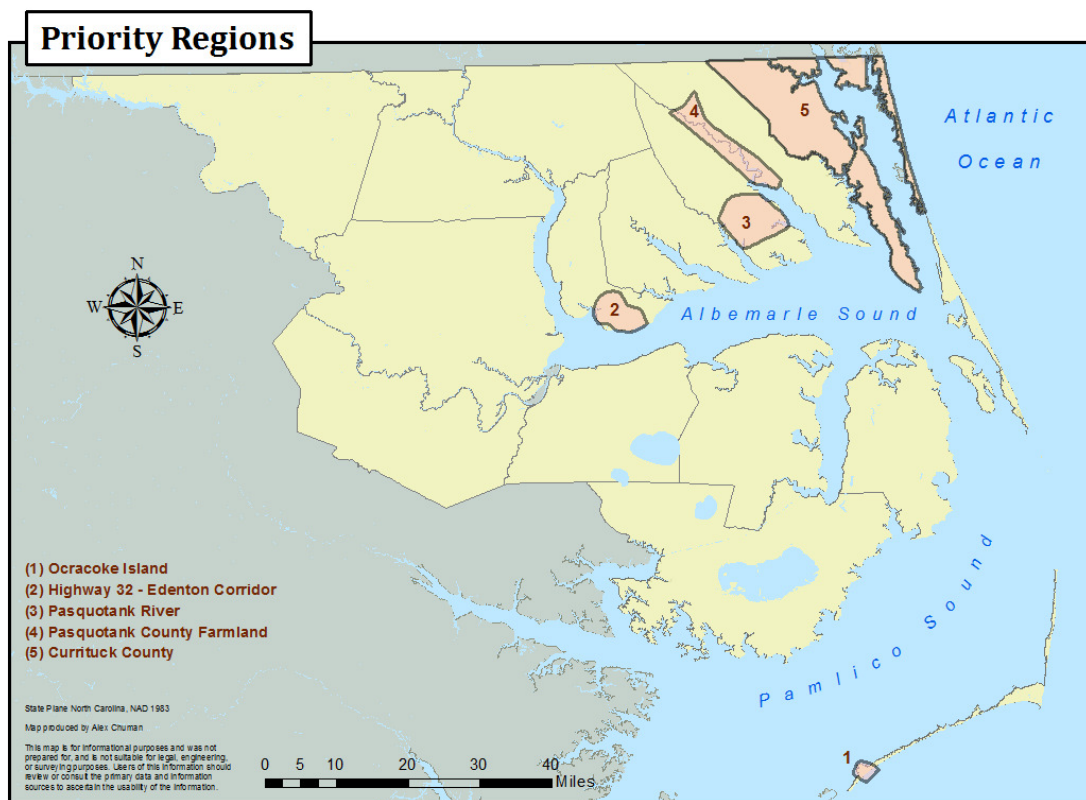


Figure 4: Parcel level prioritizations were run on five priority regions, shown in pink above.

Ocracoke Island

Ocracoke Island is located along the Outer Banks between Portsmouth and Hatteras Islands, and features a 13 mile stretch of the Outer Banks Scenic Byway (Figure 5). Much of Ocracoke Island is owned by the National Park Service, which controls the island's beaches and most of its land as part of the Cape Hatteras National Seashore. The village on the western side of the island is largely composed of private residences and businesses. The population of permanent residents on Ocracoke was 948 in 2010, and grows significantly during tourist seasons (US Census Bureau 2010). The village, which is

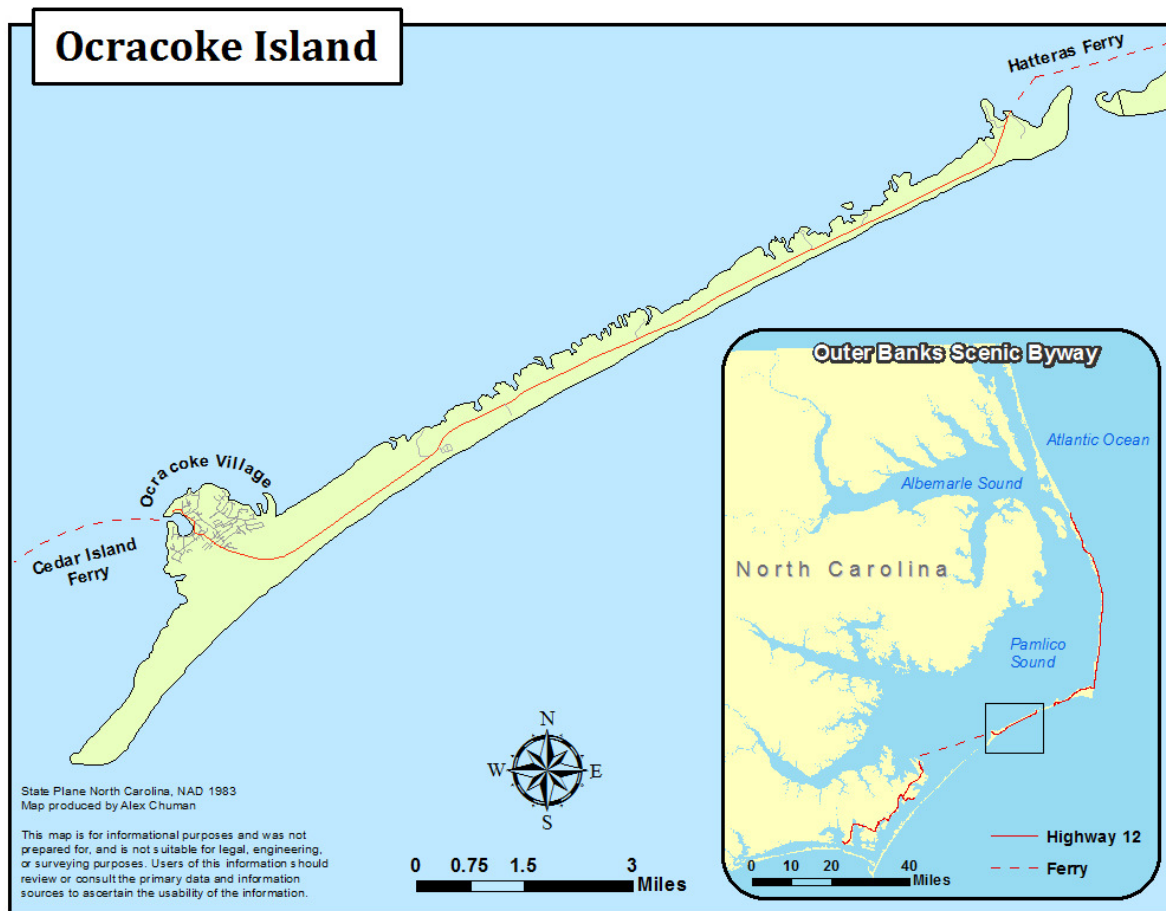


Figure 5: Map of the Ocracoke Island Priority Area. All remaining privately owned parcel are located in the village on the western side of the island.

listed on the National Register of Historic Places, is a destination for many Outer Banks travelers.

Privately owned undeveloped parcels still exist on the borders of the village, and if developed, could be a significant detriment to wildlife and the scenic viewshed of travelers. The majority of these parcels are

also dominated by wetlands which in general provide numerous ecosystem services such as water quality enhancement, flood control, and wildlife habitat (Woodward and Wui 2001, Mitsch and Gosselink 2007). The island features critical habitat for colonial waterbirds, shorebirds, and other wildlife through its salt marshes, sand dunes, and maritime forest. The NCCLT has already purchased Springer's Point Preserve, a 122 acre publicly accessible nature preserve on the western end of the village that has been a great success for Ocracoke's resident community and the NCCLT's conservation goals. The Preserve is enjoyed and widely used by both local residents and island visitors alike.

Edenton – Highway 32 Corridor

The Edenton – Highway 32 Corridor Priority Area in Chowan County follows a 1.5 mile buffer along scenic Highway 32 between Edenton and the Houghton Road Bridge across Albemarle Sound (Figure 6). After driving north over Albemarle Sound, Highway 32 and Highway 34 branch off to lead into

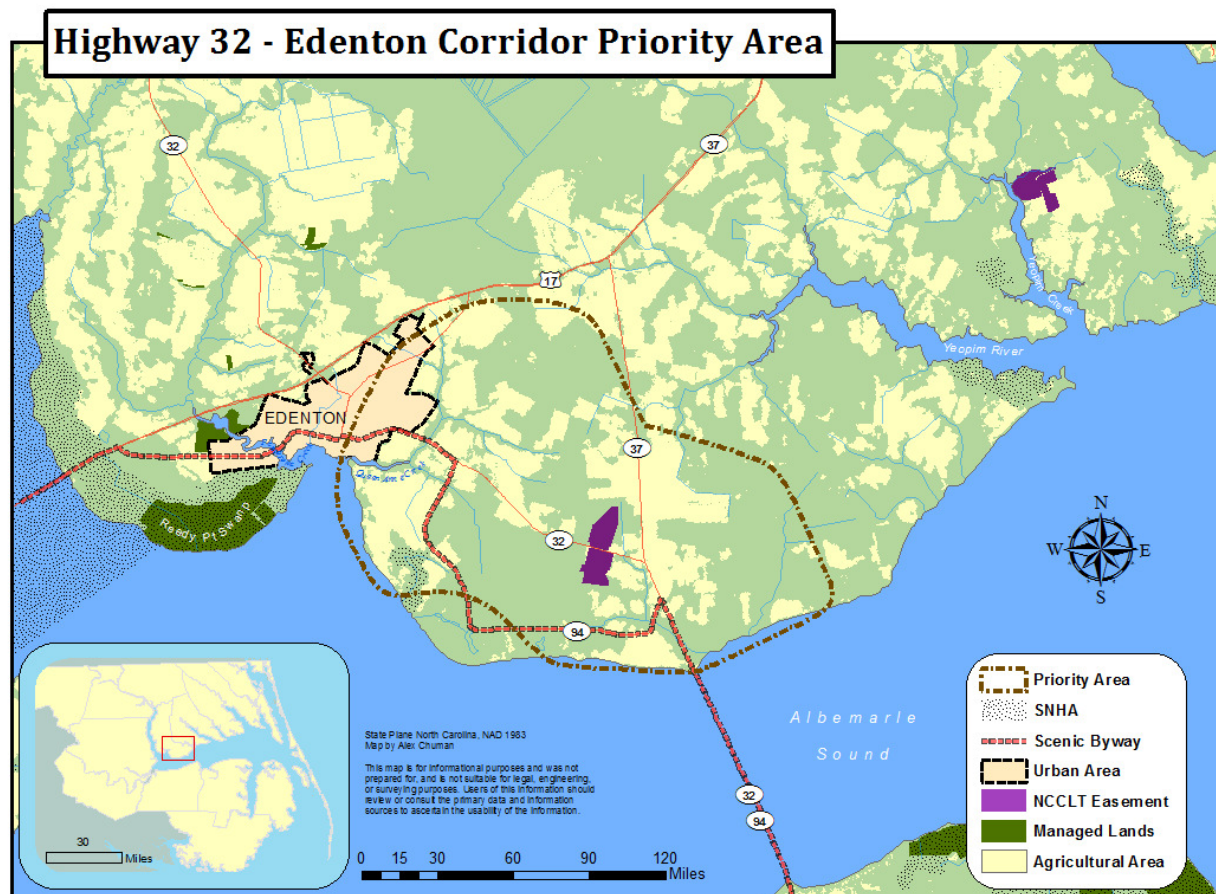


Figure 6: Edenton-Highway 32 Priority Area. This area lies along a NC Scenic Byway and includes significant riparian frontage and farmlands.

historic Edenton to the west. Edenton, founded in 1712, has a population of approximately 5,000 and is home to many historic buildings. A section of the Edenton-Windsor North Carolina Scenic Byway stretches from the bridge along Highway 94 into Edenton. The priority area has numerous agriculture fields, but also includes an airstrip, timber properties, significant wetlands, floodplain forests, and dry-mesic oak forest. Major waterways include Queen Anne Creek that runs southeast of Edenton into the priority area and Pembroke Creek that runs through the southwest border of Edenton. Middleton Creek, a tributary of the Yeopim River also runs to the border of the priority area. Cherry Point Woods falls at the southwest edge of the priority area along the coast adjacent to Edenton Airport. Reedy Point Swamp is located to the southwest of Edenton outside the priority area. The NCCLT currently has an easement on a 255 acre farm on Highway 32. The farm includes agricultural lands, pasture, managed timber, and old growth hardwood stands as well as a historic plantation home built in 1853.

Pasquotank River

The Pasquotank River Priority Area includes parcels buffering the Pasquotank River extending from Elizabeth City to the Great Dismal Swamp on the border of Pasquotank and Camden counties (Figure 7). The area has large tracts of swamp and floodplain forests along the river as well as farmlands. Major communities along the Pasquotank in the study area include cypress-gum swamp, coastal plain bottomland hardwoods, and peatland Atlantic white cedar (*Chamaecyparis thyoides*) forest. The region follows two major highways, Routes 17 and 343, from Elizabeth City north towards Virginia, which make the area susceptible to sprawling development from Elizabeth City as well as commuters from southern Virginia metropolitan areas. Soils in the area are primarily hydric, although many have been extensively drained. Upland sites are thus more suitable for urban areas and agriculture while wetland sites are generally forested. The NCCLT has been active in this region, and has multiple easements in the area.

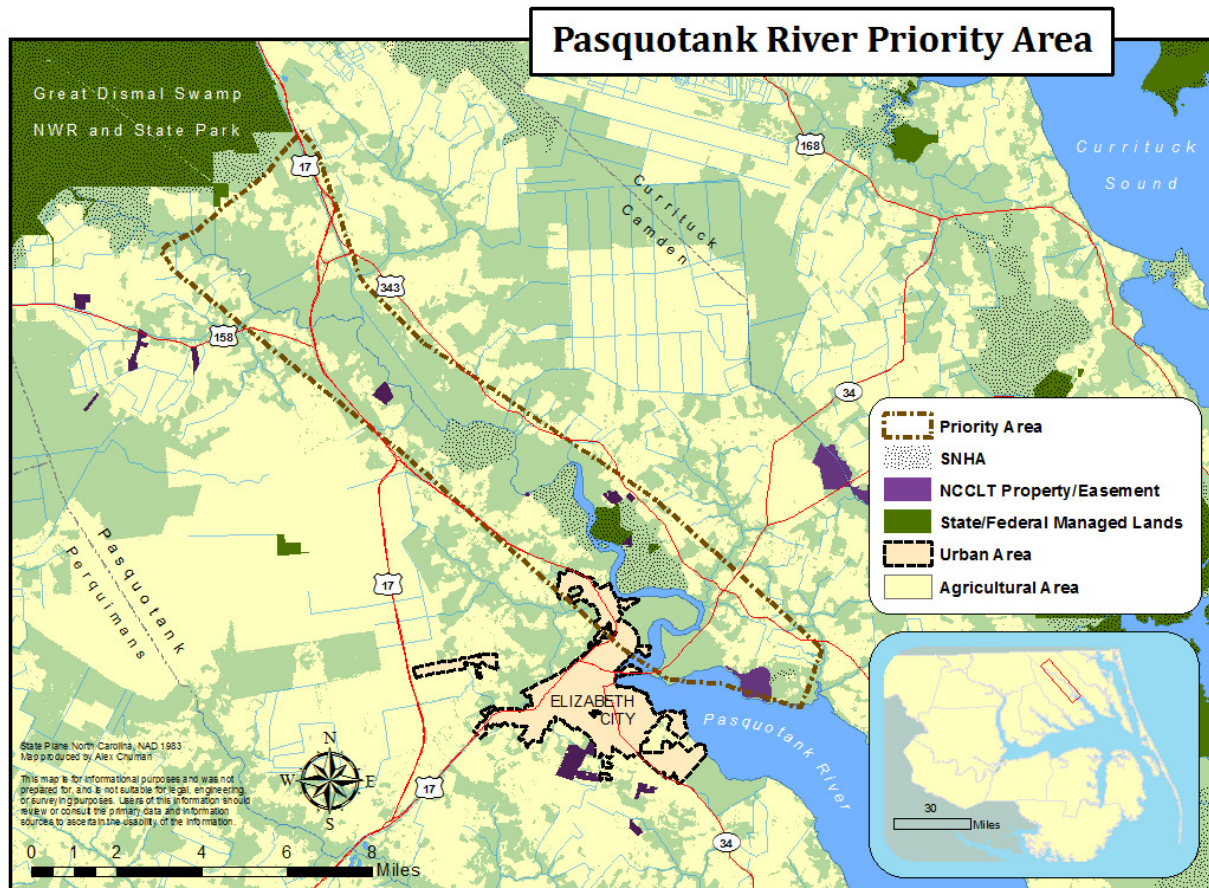


Figure 7: Pasquotank River Priority Area. This area follows the Pasquotank River from Elizabeth City to the Great Dismal Swamp.

Pasquotank County Farmland

The Pasquotank County Farmland Priority Area extends along the Pasquotank peninsula from Elizabeth City to New Begun Creek and Symonds Creek (Figure 8). The Pasquotank River lies to the east and the Little River to the west. The area consists of almost entirely prime farmlands soils and is dominated by agriculture. Pasquotank County is also part of a Voluntary Agriculture District. Land cover that is not agriculture is mostly floodplain hardwood forests along creeks and streams. Route 344 is the only major road through the priority area, which follows the Pasquotank to the end of the peninsula. A Coast Guard base also borders the priority area southeast of Elizabeth City along the Pasquotank River. The NCCLT holds easements on three farm tracts at the northern end of the area close to the border of Elizabeth City. Farmland in the priority region of Pasquotank County has a high potential of development sprawl from Elizabeth City and from commuters to southern Virginia.

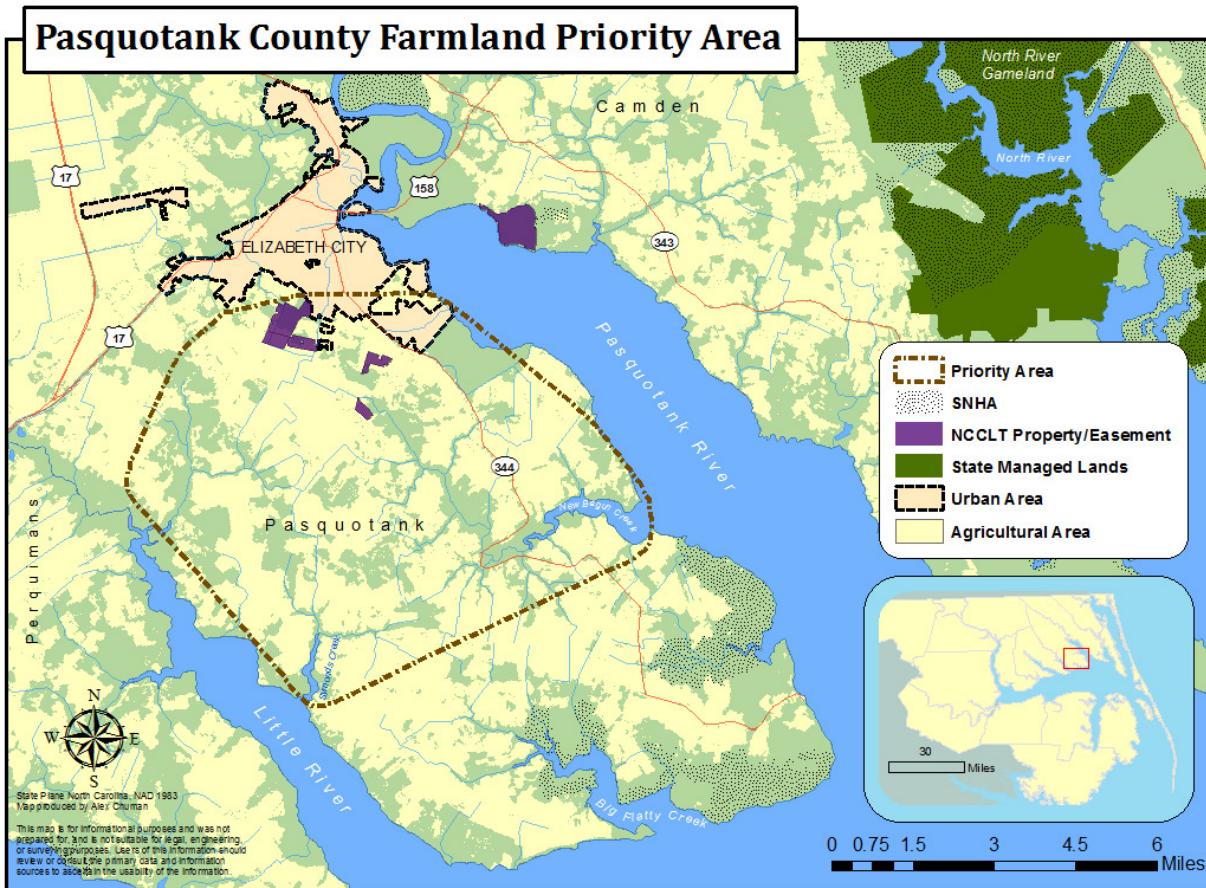


Figure 8: Pasquotank County Farmland Priority Area. This area is primarily farmland and provides opportunity to protect working lands within the vicinity of Elizabeth City and multiple SNHAs.

Currituck County Farm and Forest Lands

Currituck County is North Carolina's most northeastern county bordering Virginia (Figure 9). The two defining water bodies in the county are Currituck Sound which separates the mainland from the Outer Banks section of the county, and the North River, which lies along the county's southwest border. Major managed areas include Mackay Island National Wildlife Refuge to the north bordering Virginia, Currituck NWR along the Outer Banks, Pine Island Audubon Sanctuary along Currituck Sound, North River Game Lands, and Northwest River Marsh Game Land along the northwest Virginia border. Much of Currituck is located near metropolitan areas in Virginia of Norfolk and Virginia Beach, and thus

susceptible to sprawling development. Currituck's abundance of waterfront property may also make it a desirable location for commuters into Virginia. Currituck County is a priority area to the NCCLT due to its risk of development, numerous SNHA and managed areas, and miles of riparian frontage. Land cover in Currituck County includes agriculture,

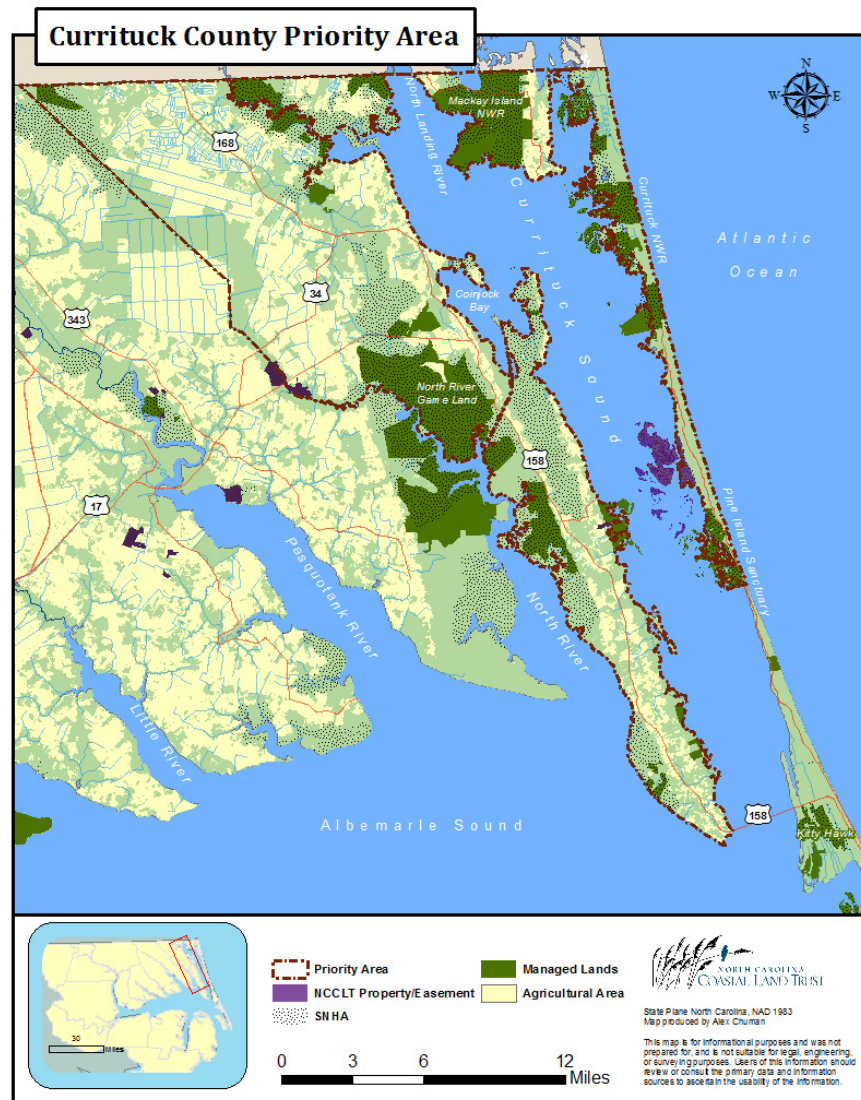


Figure 9: Currituck County Priority Area. This area is both covered in natural heritage sites and has increasing development threat from Virginian metropolitan areas.

particularly in the northwest part of the county, salt marsh along Currituck Sound, and extensive swamp forests in the North River floodplain. Currituck is located within the Pasquotank River Basin and the mainland is drained by the North, Northwest, North Landing Rivers, and Currituck Sound.

Selection Criteria and Indicators:

In order to determine conservation value of parcels, criteria were established to measure conservation value, and indicators were developed within each criterion. NCCLT staff were consulted to determine which criteria and indicators to include in the prioritization analysis. Criteria selection was based on both expert opinion as well as available data. The criteria chosen include parcel size,

biodiversity and wildlife habitat, connectivity with existing NCCLT lands and managed areas, development threat, and water frontage/water quality potential. Each of these criteria were measured by indicators, shown in the objectives hierarchy below (Figure 10). Scenic opportunity was only used in the Ocracoke analysis, which has a National Scenic Byway running through the village. Parcel analyses involved a ruled based GIS method using ArcGIS v10.1 (Esri 2012). Data sources for all GIS data for the indicators and criteria are shown in Table 1. The following six criteria were used in the focus regions to prioritize lands.

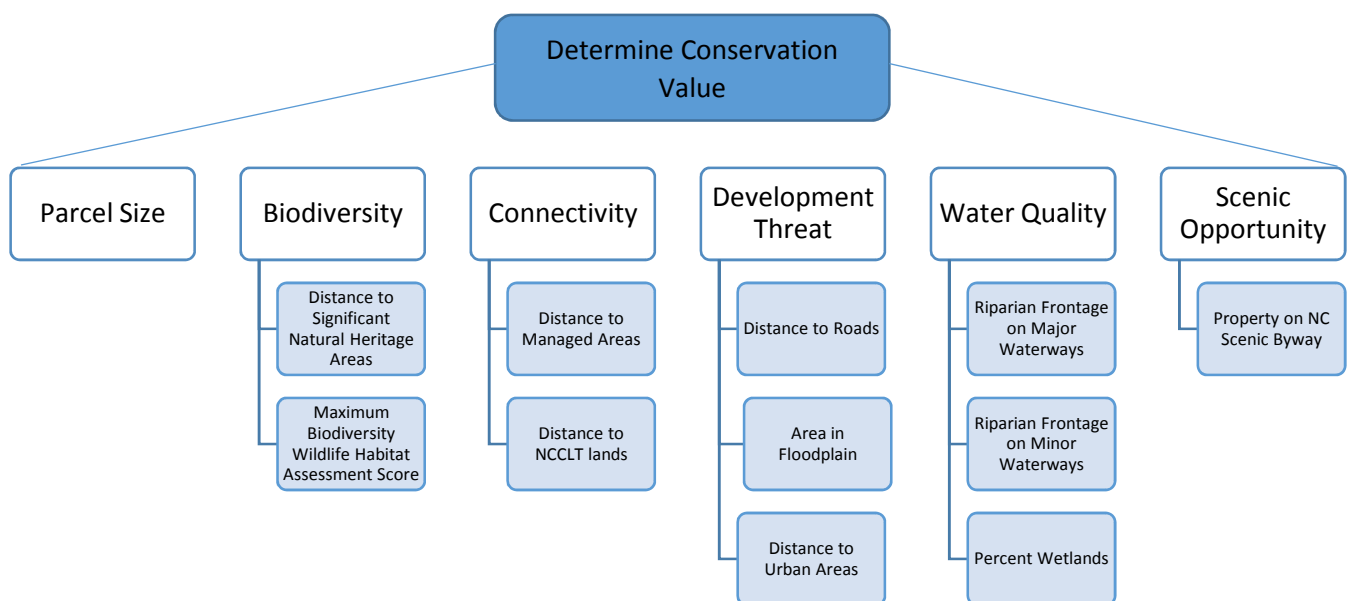


Figure 10: Objectives Hierarchy. The overarching goal of this study is to determine conservation value for individual parcels in each study area (blue). The criteria to evaluate this goal are the next tier of the hierarchy (white). In the next tier, indicators show how each criterion is measured (grey).

Parcel Area:

Land trusts can more effectively manage and devote resources to a small number of large parcels compared to numerous, small and fragmented parcels. Larger parcels provide a greater scenic impact and more core habitat. Acreage was classified for each region in two ways. First, the smallest parcels were excluded at a threshold specific to each priority area. Acreage was then divided into 3 utility classes depending on overall size of parcels in the priority region (see the Utility Analysis and Weighting

section for exclusion thresholds and utility classes). Largest parcels received the most points and smallest the least.

Connectivity to other Conservation Lands

Connected lands are more efficiently managed and create larger patches of pristine habitat important for many types of wildlife. Connectivity of managed lands also may provide migration corridors for species dispersed from encroaching development or sea level rise. Points were assigned based on distance of parcels to both managed lands (NCHP 2013) and already existing NCCLT properties (distances and threshold values noted in next section).

Biodiversity

Two indicators were used to determine ecologically valuable lands. These included the distance to Significant Natural Heritage Areas and the BWA tool, where the maximum BWA score in any parcel was considered. Each received 50% contribution as indicators in the biodiversity criterion, but can be adjusted accordingly if desired. The Biodiversity/Wildlife Habitat Assessment tool developed by the NC Natural Heritage Program incorporates wildlife habitat (50%), terrestrial and aquatic biodiversity (25%), and priority ecological systems (25%) to rank conservation value of land in North Carolina on a scale from 1 (Moderate) to 10 (Highest) (NCNHP NCPT 2013). The model incorporates twenty-seven different datasets to rank conservation value of lands. Data inputs include Significant Natural Heritage Areas; presence of rare species; wildlife habitat and connectivity; aquatic resources like trout streams, fish nursery areas, and outstanding resource waters; wetlands; and important watersheds. Average and highest score of each parcel's BWA score was recorded and classified for each priority region, but maximum score was used in the prioritization analysis.

Development Threat

The goals of most land trusts are to protect undeveloped lands from development in the future. Thus development threat was used as a criterion. Three different indicators were used to judge development

threat. These included distance to nearest public road, distance within already urban areas, and presence of parcel in the 100 year floodplain. The parcels with easy road access off of major highways and within urban boundaries were judged to be more susceptible to development risk. Since limitations on development generally exist in the floodplain and on hydric soils, parcels within the floodplain and dominated by hydric soil were considered less likely to be developed for this criterion.

Water Frontage and Quality

Parcels located adjacent to riparian areas and the coast have great potential to better water quality, provide habitat, and have greater possibility of obtaining grant money for projects. Riparian frontage on major waterways and the coast, riparian frontage on minor waterways, and presence of NC-CREWS wetlands were used as indicators for properties that can have positive impacts on water quality.

Land Cover

While land cover was not used for the majority of the prioritizations dictated by the NCCLT's preference, a land cover criterion was included in the GIS tool developed. This criterion provides useful information on farmland, forest, and developed percentage land within each parcel that can be used in future analyses.

Scenic Opportunity

NCCLT does not generally use Scenic Byways as a criterion for project selection, but this criterion was included in the tool if future grant opportunities exist involving Scenic Byways funding. The Ocracoke Island parcel is an example of this case. Furthermore, location of a parcel on a Scenic Byway likely means the parcel is particularly scenic and surrounded by either undeveloped or historically relevant lands.

Table 1: Data sources used in the GIS analysis. The most recent parcel data available was used, but this varied between counties.

Table 1: GIS Data Sources	
Criteria/Indicator	Data Source
Parcel Size	Tax Parcel Shapefiles from Currituck, Camden, Chowan, Pasquotank, Perquimans, and Hyde Counties
Biodiversity <ul style="list-style-type: none"> • SNHA • BWAH 	North Carolina Natural Heritage Program (2013) http://www.ncnhp.org North Carolina Natural Heritage Program (2013) http://www.ncnhp.org
Connectivity <ul style="list-style-type: none"> • Managed Lands • NCCLT lands 	North Carolina Natural Heritage Program (2013) http://www.ncnhp.org NCCLT GIS data (2013)
Development <ul style="list-style-type: none"> • Roads • Urban Areas • % Floodplain 	Tiger Shapefile (2013) http://www.census.gov/geo/maps-data/data/tiger-line.html NCDOT Smoothed Urban Boundaries (2013) data.nconemap.com NC Flood Risk Information System (2012) http://www.ncfloodmaps.com
Water <ul style="list-style-type: none"> • Waterways • Wetlands 	NC Center for Geographic Information and Analysis data.nconemap.com NC-CREWS wetlands (2008) http://dcm2.enr.state.nc.us/wetlands/download.htm
Land Cover	NLCD Landcover 2006 http://www.mrlc.gov/nlcd2006.php
Scenic Byway	Created from Tiger Shapefile (2013) & NCDOT Scenic Byway Maps (2008) http://www.census.gov/geo/maps-data/data/tiger-line.html http://www.ncdot.gov/travel/scenic/

Utility Analysis and Weighting

After priority regions were determined, criteria and indicators were selected, and necessary data obtained, the next step was to perform a utility analysis on criteria and indicators. In a utility analysis, scales from 0 to 1 are developed to determine how points are assigned within each indicator, and then the indicators are weighted to determine a final utility value for each criterion. Finally, these utility values for the criteria are multiplied by weights and summed to obtain a final conservation score. The analysis performed used an equal weighting method across all criteria. For example, in an equal

weighting scenario, if the 5 major criteria were used in the prioritization analysis, each criterion is multiplied by 20%, or 0.20 using a scale from 0 to 1. These final values are then summed to determine a parcel's conservation score.

For this analysis, parcels in each study area were excluded if the land was already managed for conservation or owned by a public entity. Parcels less than 50 acres were also excluded in Pasquotank River, Pasquotank Farmland, and Edenton areas. In the larger scale Currituck analysis, parcels less than 100 acres were excluded. Original weighting of utility within each indicator was performed with input from NCCLT on a 0-5 point scale. This was converted to a 0 to 1 scale for consistency in future weighting. For example, a previous value of 3 out of a maximum 5 was converted to 0.6. Because criteria varied significantly between priority regions, utility values for size were determined specifically for each priority area. Prioritization results are therefore not meant to be compared between regions. For example, parcels that score highly on the small scale Ocracoke are not necessarily equivalent to parcels that score highly on the larger scale Currituck County. All thresholding and utility values cut-offs are shown in Figures 11 and 12. After scales were developed for each indicator, indicators were then weighted into each criterion to develop a utility score for each criterion (Table 2). For example, the connectivity criterion includes 50% input from distance to managed lands and 50% from distance to NCCLT lands. Once each parcel had an associated utility score for each criterion, weights were applied for each criterion to determine the final conservation scores of each parcel. For this report, an equal weighting scenario was used in each priority region (Table 2). In the Edenton priority region, six different weighting schemes were used to show an example of how criteria weighting can alter results.

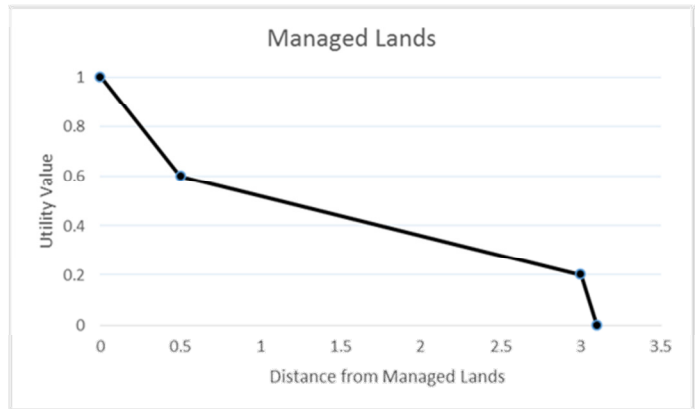
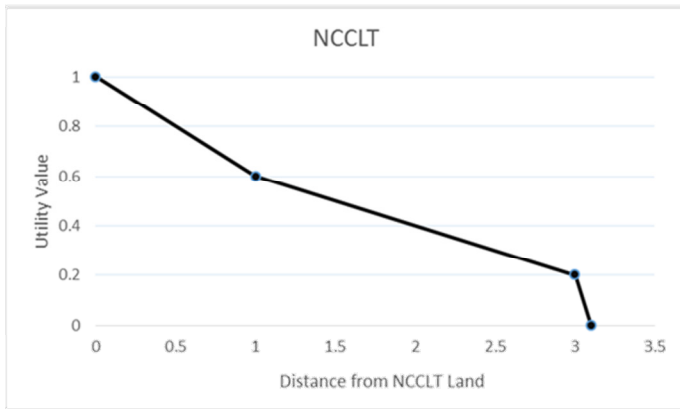
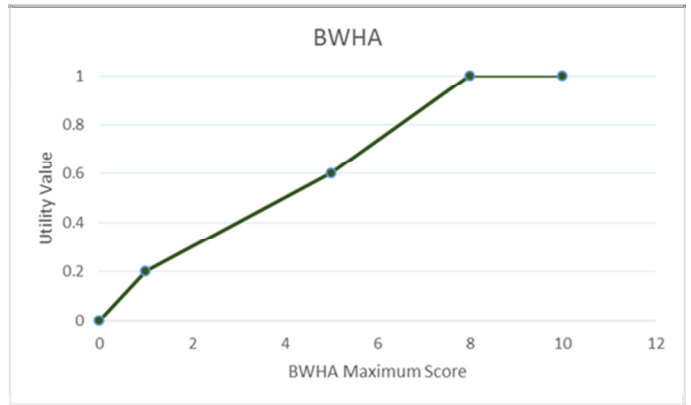
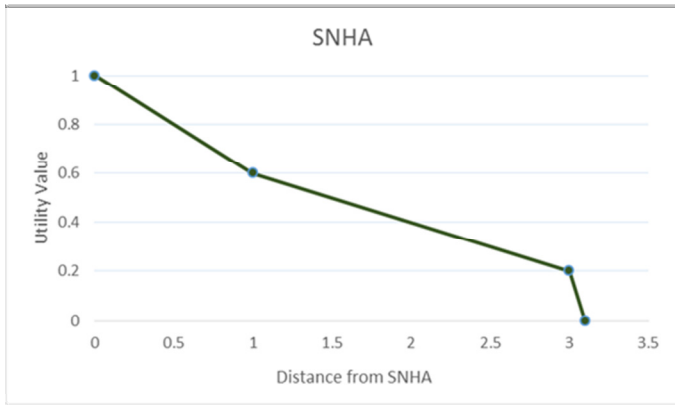
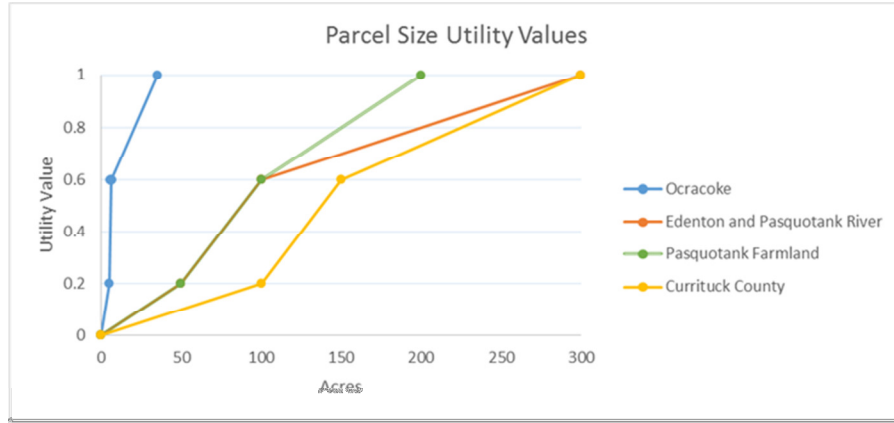


Figure 11: Utility Scales are shown for size for all regions, biodiversity indicators (green), and connectivity indicators (black).

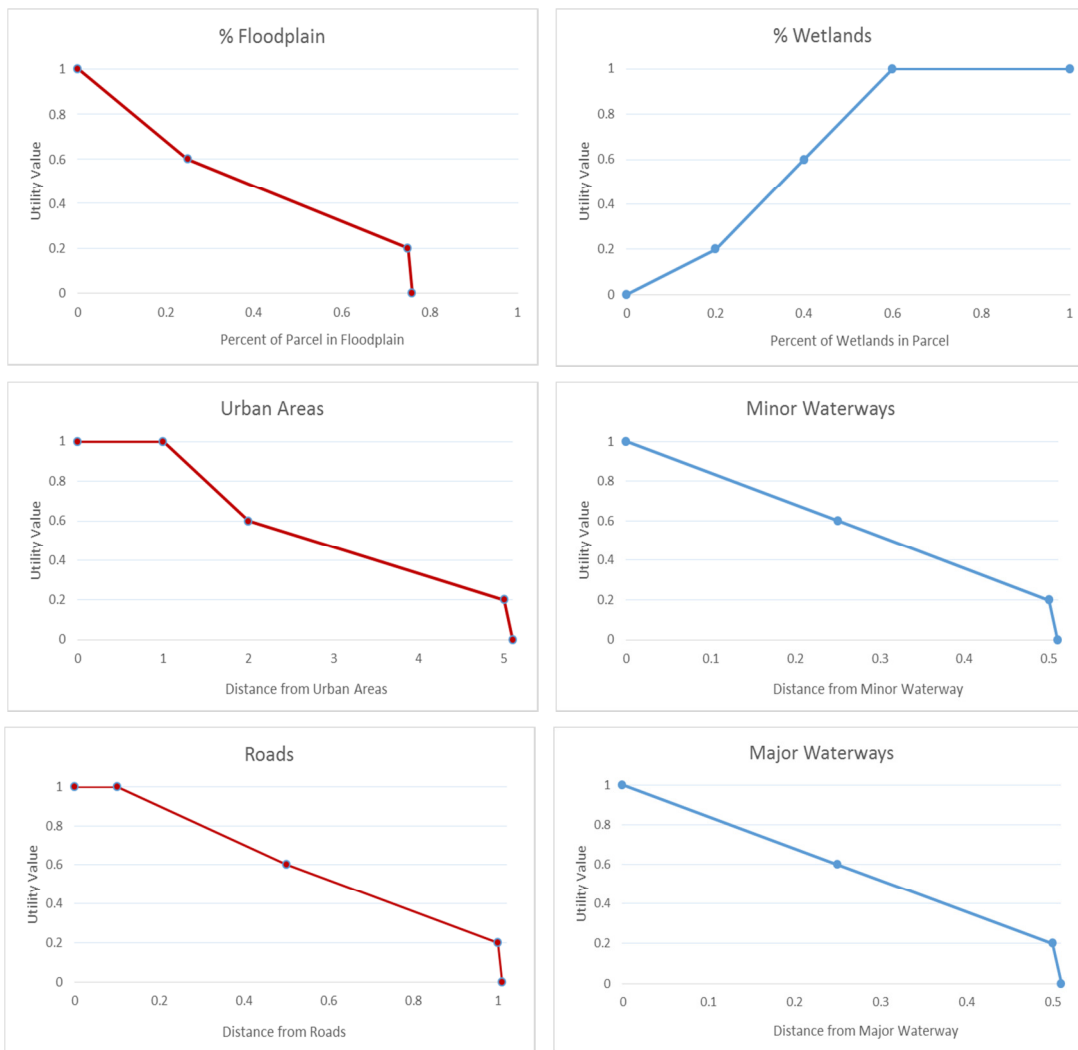


Figure 12: Utility Scales for the water (blue) and development (red) indicators.

Table 2: Indicator weights presented here were used in all analyses in this report, but can be changed as desired with the GIS tool. An Equal weighting scheme of all 5 of the criteria is also shown. Scenic Byway was only used in Ocracoke.

Criteria	Indicator	Indicator Weight	Criteria Weight (Equal Weighting)
Size	Size	100%	20%
Biodiversity	SNHA	50%	20%
	BWHA	50%	
Connectivity	NCCLT	50%	20%
	Managed	50%	
Development	Roads	40%	20%
	Urban Area	40%	
	Floodplain	20%	
Water	Major	60%	20%
	Minor	30%	
	Wetlands	10%	
Scenic Byway*	Byway	100%	0 (Only used in Ocracoke)

GIS Prioritization Tool

The GIS Prioritization tool developed follows the methods process outlined earlier but allows for user defined prioritization. That is, the user can define the threshold values, utility values for all indicators, weights of the indicators in each criterion, and the final weights assigned for each criterion. The tool requires two major sets of inputs. The first input is the associated vector or raster input environmental layers and the second is a set of parcels in the study area. The tool is designed to run for a specific priority area. In the case of this study, the tool would thus be run 5 separate times for each unique priority region. Detailed instruction can be found in the Appendix and as documentation embedded in the tool.

There are four major phases to the Land Prioritization tool. The first creates a summary table based on criteria given for each parcel in the study area. For example, a summary table will show the attributes of each parcel including acreage, distance to nearest stream, and so on. Such a table is useful to collate all information for a given parcel with minimal effort.

As part of phase 2, utility values are assigned by the user on a scale of 0 to 1 for each criterion through a series of if-then queries. For example, a study region may have parcels that range from 0 to 1000 acres. The user would define separate classes to assign utility values. An example might be parcels greater than 500 acres are assigned a value of 1.0, parcels from 250 to 500 acres = 0.6, parcels from 50-250 = 0.2, and parcels less than 50 acres are assigned 0 points. The ability for the user to define utility values in the actual GIS prioritization is distinct from previous similar prioritization projects (Jacobson 2010, Hoenke 2012) and adds a layer of versatility for the user. At the end of this stage, a new table will show each parcel and its associated utility values for each of the indicators.

The third phase allows the user to define weights of the indicators in each criterion. For example, the user may have a connectivity criterion that accounts for 50% managed lands and 50% NCCLT lands, or the user could weight these indicators 75% NCCLT and 25% managed. Any scheme may

be applied as long as the total sums to 100%. The end result of this phase is a utility value for each criterion in each parcel.

The final phase requires the user to weight the different criteria used based on their importance. These criteria could be weighted equally, as done in this study, or could be altered to weight certain criteria more than others. To demonstrate this, the Edenton-Highway 32 area was run under 6 different weighting scenarios. The final result of this phase is a set of results tables and an ArcGIS shapefile of parcel identification numbers and the total conservation score for each parcel. The tool also includes an appendix to calculate land cover separately in each parcel if desired by the user.

Criteria to include in the tool were based on discussion with NCCLT as well as criteria that may be useful to conservation organizations in future analyses. While this tool was designed for use in North Carolina, it can easily be altered to use in different regions. The Land Prioritization tool was also used with point values and a weighting system influenced by the NCCLT, but these values could easily be adjusted in future scenarios.

Ground-truthing

GIS data layers do not always reflect ground conditions accurately. Therefore, priority regions were visited in the summer of 2013. While each parcel was not examined in significant detail, particularly in the largest regions, visiting the regions allowed for any major discrepancies between GIS data and on-the-ground conditions to be noted. If the NCCLT decides to pursue lands in the future, more detailed site visits will be necessary to ensure GIS layers represent the land accurately.

RESULTS

The GIS prioritization tool successfully ran specialized prioritization scenarios for each priority area. The conservation values of each priority area are separated from highest value parcels (1) to lowest (0) along a relative scale. As noted, the following results reflect indicator weights in Table 2 and equal weighting of the criteria. Symbology is classified by equal interval breaks.

Ocracoke Island

A total of 15 parcels were included in the Ocracoke analysis. The highest ranked parcel on Ocracoke Island was Parcel 1, which is surrounded on three sides by NCCLT's Springer's Point Preserve (Figure 13). Such a parcel is highly valued to increase the size of the preserve. Parcels of lowest conservation value are small parcels located furthest from the coast. Ocracoke is a unique priority area due to its small size and the inclusion of Scenic Byway visibility as a criterion.

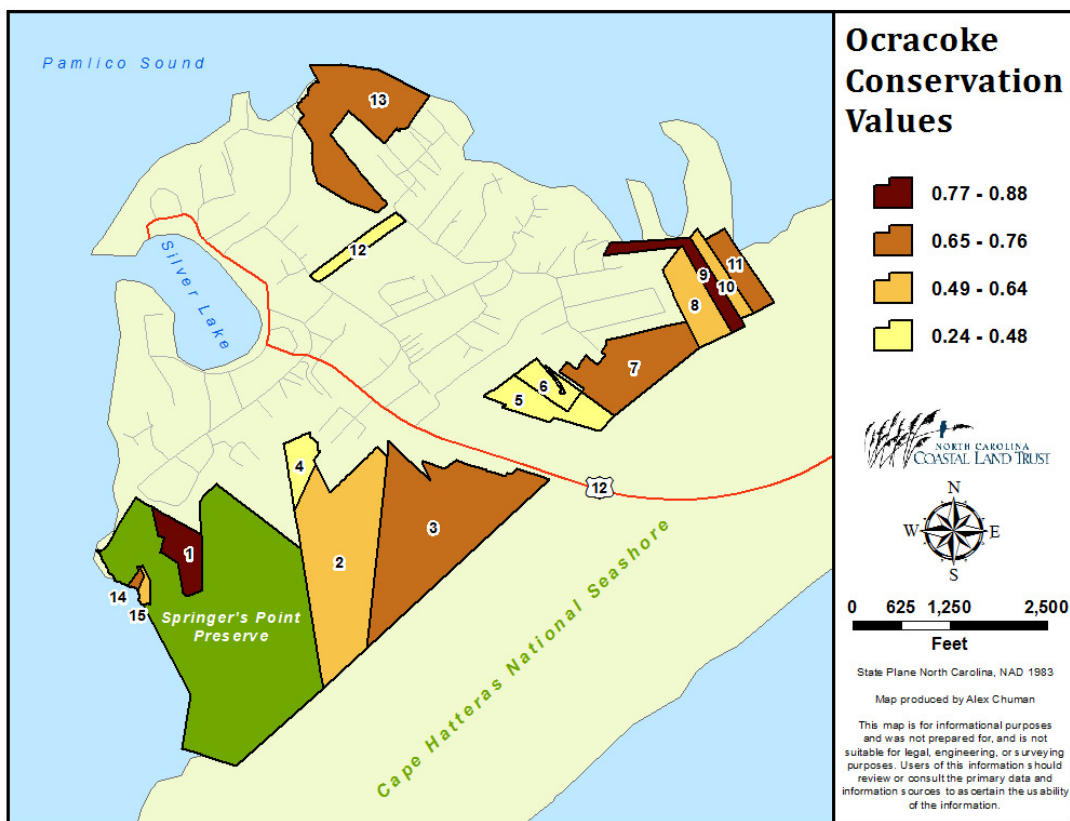


Figure 13: Conservation values of parcels on Ocracoke Island in an equal weighting scenario. The Scenic Byway criteria was also included in the Ocracoke region.

Edenton – Highway 32 Corridor

After elimination of parcels below 50 acres, 51 parcels remained in this priority area. Two trends can be seen in the Edenton-Highway 32 Corridor results (Figure 14). First, parcels located near Edenton on Albemarle Sound scored highly, and second, parcels located between the NCCLT easement and Albemarle Sound were also scored highly. These parcels have a combination of high connectivity value, threat of development, and riparian frontage scores.

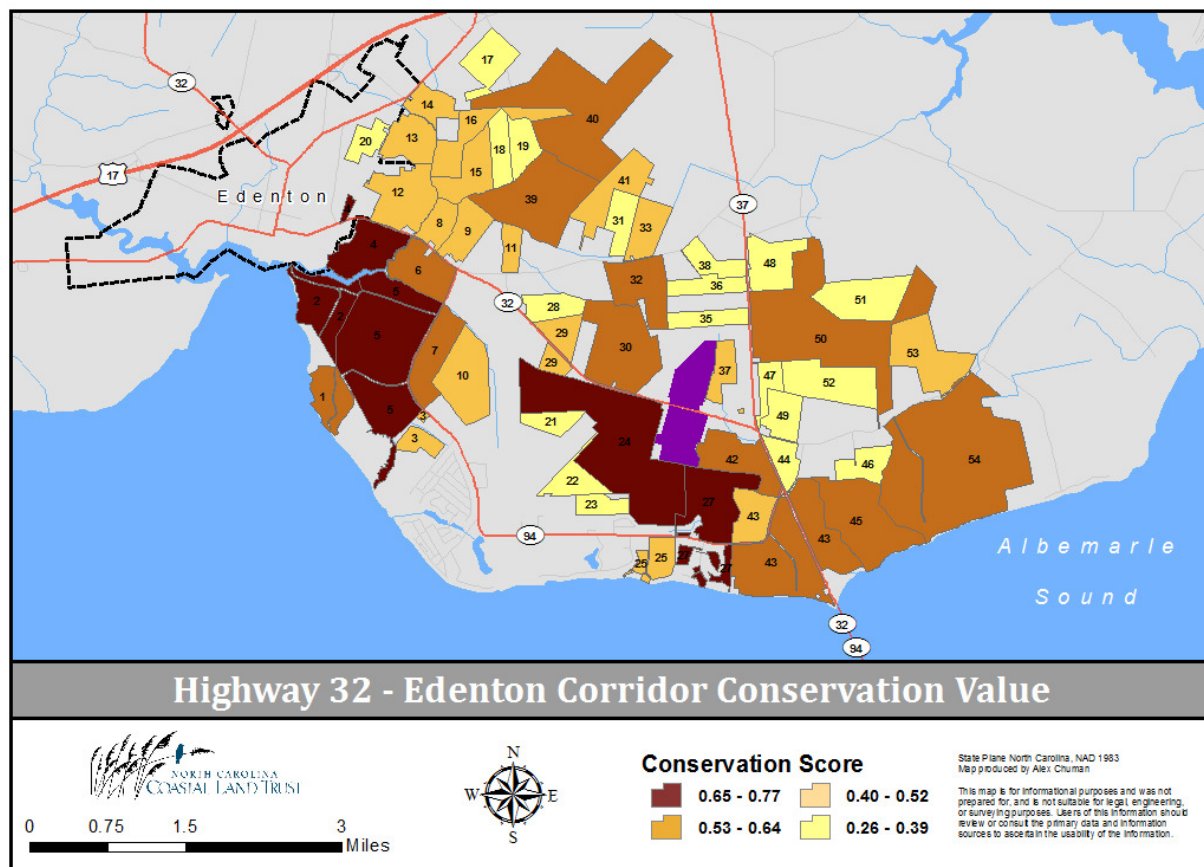


Figure 14: Edenton-Highway 32 Conservation values with equal weighting. An NCCLT easement is shown in purple.

Pasquotank River

This priority area included 146 parcels. Parcels of high conservation value are located across the length of the Pasquotank River, with the highest scoring parcels located generally closer to Elizabeth City (Figure 15). Notably, high conservation values tend to either be exceptionally large or adjacent to NCCLT properties. Most of the lowest value parcels are located at the northwestern edge of the study area.

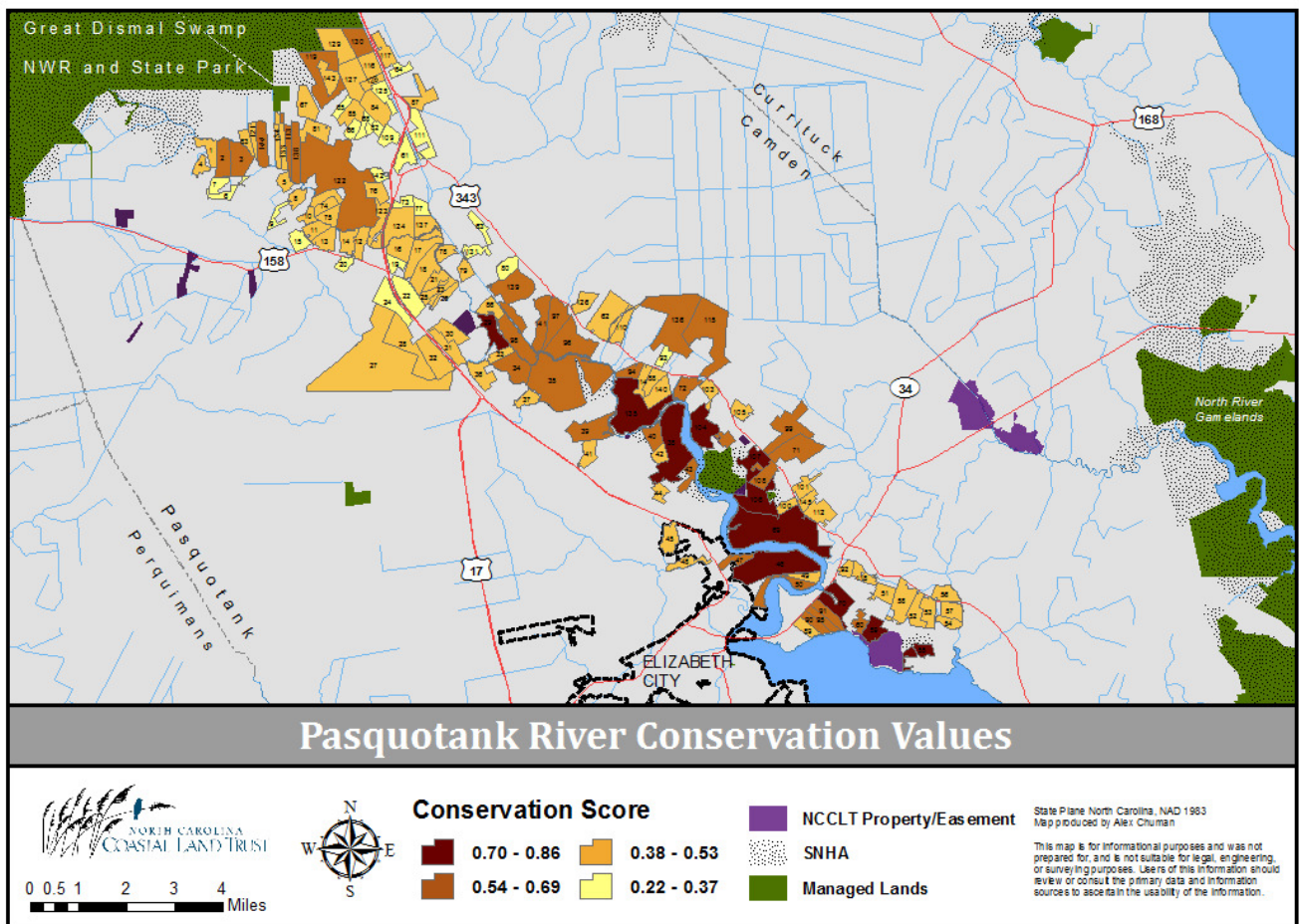


Figure 15: Pasquotank River conservation values with equal weighting.

Pasquotank County Farmland

Of the 159 parcels over 50 acres, those that scored particularly highly are concentrated near existing NCCLT lands located close to Elizabeth City (Figure 16). These parcels are scored as being at greater risk of development and have strong connectivity value. Parcels in this priority region had lower overall scores than the other regions.

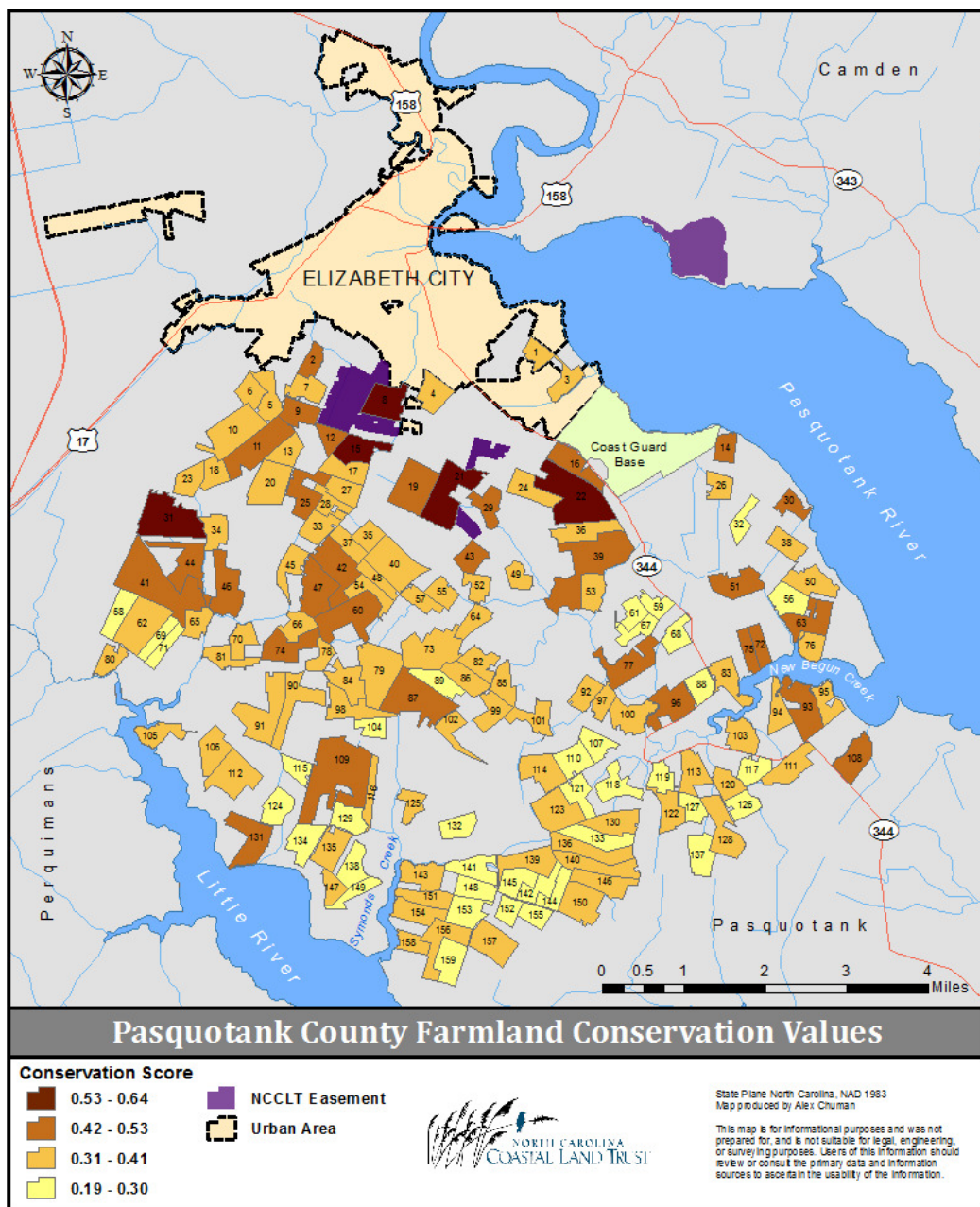


Figure 16: Pasquotank County Farmland conservation values with an equal weighting scheme.

Currituck County Farm and Forestlands

The Currituck County analysis is a larger scale analysis, including 233 parcels after thresholding to 100 acres. Results showed highly valued parcels located across the county, with concentrated areas of highly ranked parcels along Currituck and Albemarle Sounds and near the Virginia border.

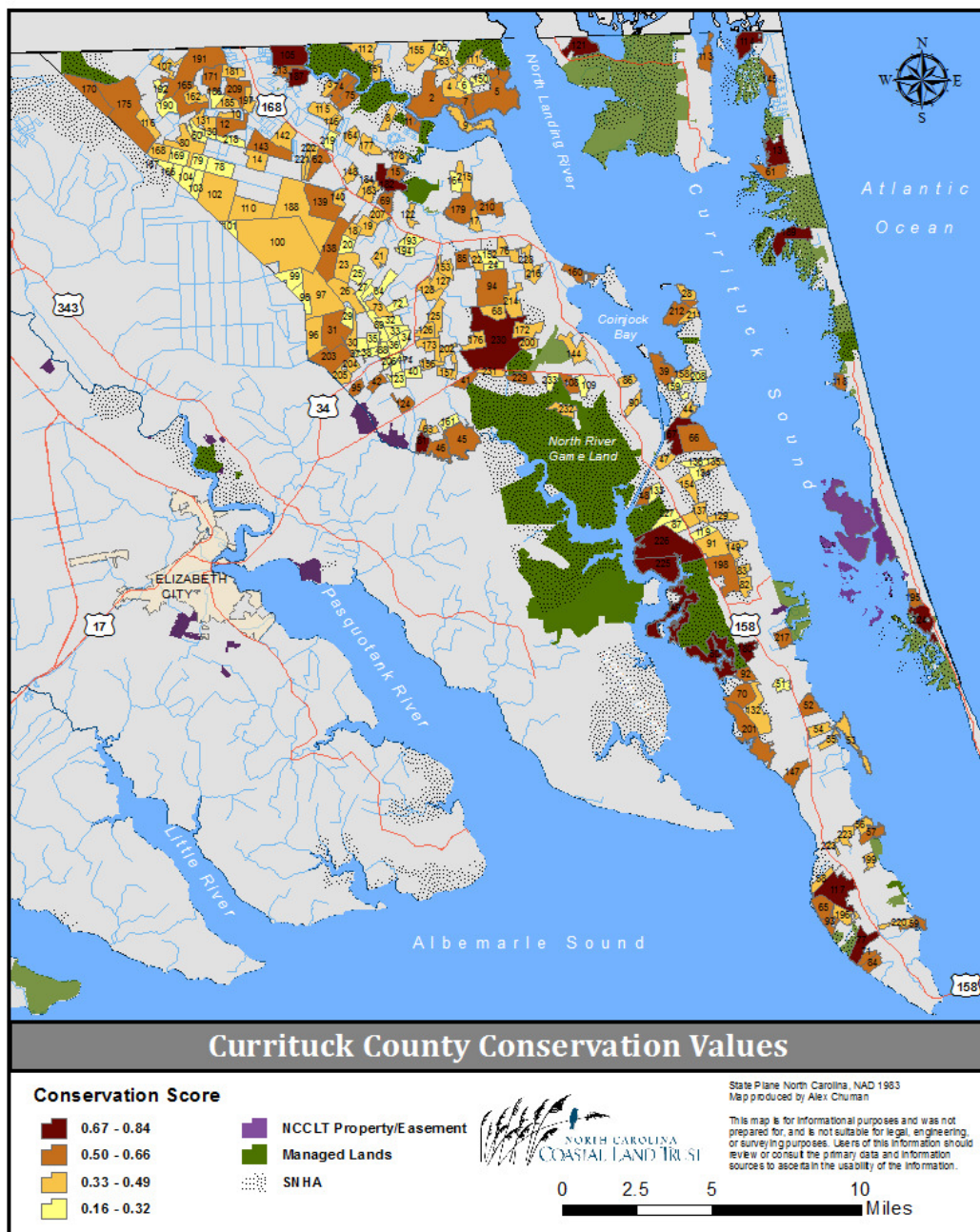


Figure 17: Currituck County conservation values with an equal weighting scheme.

Applied Weighting Schemes – Edenton Example

The flexibility of the Land Prioritization tool was displayed by running 6 different weighting schemes in the Edenton-Highway 32 region (Table 3). While six possible schemes are shown here, any possible weighting scheme could be applied as long as the total weight is 100%. Results show how the final conservation value of parcels changes with different weighting schemes (Figure 18). As one example, Scheme 5 demonstrates only those parcels with connectivity scores. Scheme 3, which over-weights connectivity as well, shows a similar trend, but more variation can be seen in the other parcels, as the remaining 50% of points is distributed equally between the remaining criteria. The weighting schemes shown here as part of the GIS tool designed show how a land trust would be able to weight criteria accordingly to changing or new objectives in different regions.

Table 3: Six schemes were run with the GIS prioritization tool to demonstrate how results change with different weighting schemes.

Table 3: Edenton Alternative Criteria Weighting Schemes						
Criteria	Scheme 1	Scheme 2	Scheme 3	Scheme 4	Scheme 5	Scheme 6
Size	20%	12.5%	12.5%	0	0	50%
Biodiversity	20%	12.5%	12.5%	0	0	50%
Connectivity	20%	12.5%	50%	0	100%	0
Development	20%	12.5%	12.5%	0	0	0
Water	20%	50%	12.5%	100%	0	0

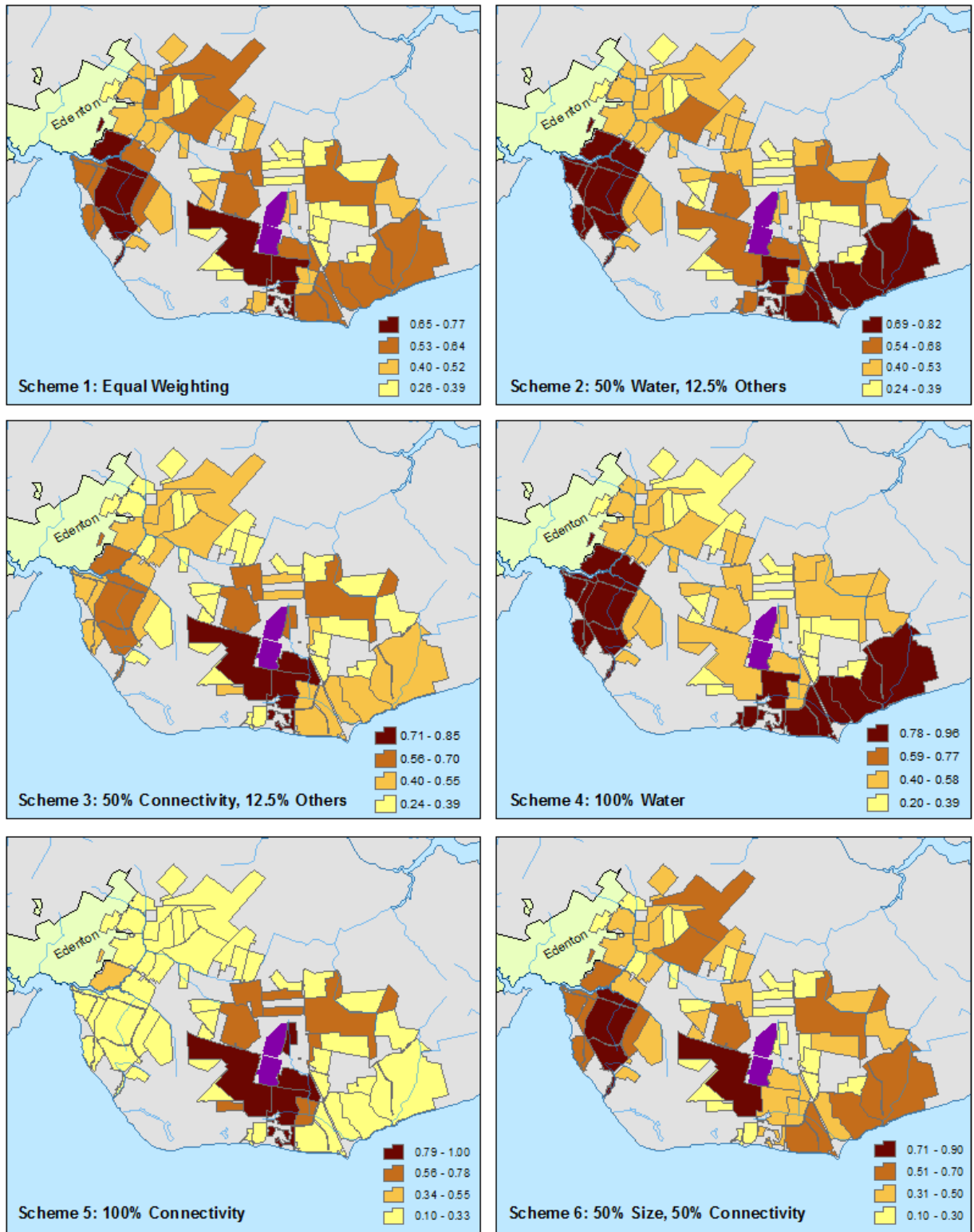


Figure 18: Six different weighting schemes are shown for the Edenton priority region. The purple parcel is a NCCLT easement. Final conservation scores differ according to the weighting scheme used. The GIS prioritization tool created allows the user to perform rapid site prioritizations like those shown here.

DISCUSSION

Site prioritizations under a decision analysis framework are useful for land trusts for a number of reasons. First, they demand characterization of what makes a parcel valuable to conserve. For example, land trusts must consider whether they value habitat more than water frontage, or perhaps whether they should prioritize lands threatened by development over other criteria. The multi-criteria decision process ensures that an organization makes well thought out decisions in a transparent process based on their overarching goals. Second, even if there is associated uncertainty, such prioritizations provide a general idea of what parcels in a focus area are of high value and for what reasons. Importantly, however, site prioritizations are a decision *support* tool. They are not meant to provide the only say in whether a parcel is worth conserving or not. Nor are the results intended to simply categorize parcels with high scores as worthy of conservation and parcels with low scores as unworthy of pursuing. The results simply provide another layer of analysis that should be considered when making land conservation decisions.

This study provides a possible conservation strategy for NCCLT as it seeks to expand conservation efforts in northeastern North Carolina. The study can also be used as a reference to quickly determine the major characteristics of a parcel if approached by interested landowners. While the prioritization final conservation score is the major focus of this report, the summary statistics table output included in the tool should not be overlooked. Such information is useful if NCCLT wants to quickly look up pertinent information for a given parcel. Rather than simply look at the parcel and overlapping layers in GIS, quantitative characteristics can be seen and used as necessary.

The GIS tool provided should enable NCCLT to performed future prioritization studies with minimal effort that can be tailored to specific focus regions. Furthermore, if NCCLT wishes to change their objective in a specific priority region, the GIS tool will enable them to quickly perform new analyses. The equal weighting case presented in this report is one proposed weighting scheme, but the

tool can be used for any alternative scheme, or simply to identify adjacent parcels to certain criteria by placing all the weight on one indicator or criteria. While designed for coastal North Carolina, a modification to this tool, or the use of similarly designed tools from other GIS analysts or students, can aid land trusts in making transparent and well thought decisions in future conservation efforts.

A multi-attribute analysis presents a transparent framework, but inherent bias still exists in the procedure in a number of ways. First, decision makers in organizations must make decisions on the initial focus area. Then, criteria must be selected, utility values assigned, and finally weights to apply to these values. Each of these steps requires educated input by the decision makers. These decision makers use relevant literature and years of knowledge and expertise in the field, but results will vary depending on the preferences of the person making the decisions. Uncertainty is also introduced in the fact that the prioritization in this analysis was based solely on a variety of GIS data layers. The parcel data was not all from the same years, and the accuracy of the environmental layers are not guaranteed to be up to date with present conditions. While some ground-truthing was performed, a much more extensive effort must be applied to rule out any uncertainty between GIS data layers and on-the-ground conditions.

Criteria to measure conservation were determined with guidance from NCCLT. It is important to note that other organizations may view conservation value differently according to the overall mission of a particular organization. A land trust that focuses on water issues may have more water focused criteria to determine value of parcels, while another land trust may include historic sites in their criteria. One of the values of the GIS tool designed is it allows weighting of different criteria if an organization values one criterion over another. However, certain land trusts may desire a wider range of criteria than the 6 criteria provided in this tool, making the tool harder to use in such situations.

Before assigning utility values, parcels were often removed if they did not meet a certain size threshold. While this measure is understandable for a land trust with limited resources to undertake, it

may remove certain parcels that have extremely valuable habitat, but are too small to be considered a worthwhile parcel. Furthermore, assigning threshold values at certain utility values does not allow separation within each classification. For example, parcels in the size range 100-200 may be assigned a utility value of 0.2. In this scenario, despite a size difference of nearly 100 acres, a parcel of 101 acres has the same value as a parcel of 199 acres.

Another potential issue with this analysis is that the criteria are not necessarily independent from one another. Thus, changing the weights of a certain criteria does not guarantee that only that criterion is being affected. For example, increasing the water quality and frontage criterion will increase the impact of riparian frontage on the prioritization. However, riparian area is likely correlated with biodiversity. As a result, the biodiversity criterion will be positively impacted from the weighting as well as the water quality criterion. The decision maker must be aware of such correlations when manipulating the weights of the prioritization tool.

Despite the uncertainty involved, site prioritizations are still useful for land trusts and conservation groups to efficiently protect lands in line with the mission of their organization. The scoring of parcels presented and scores from alternative weighting schemes can be combined with overall conservation strategies, detailed discussion of threats to the region, documented natural areas, and adaptation plans to create a comprehensive conservation plan for the region moving forward.

CONCLUSIONS

Land trusts across the country must make difficult decisions when deciding how to protect and prioritize lands in the region they work. The Land Prioritization tool designed in this study provides an opportunity for land trusts to efficiently select parcels that may be of high conservation value. This tool should not be used by itself in conservation planning efforts, but as a complement to other methods land trusts use in making decisions. Due to limited time and resources, land trusts often make decisions reactively when it comes to protecting land. However, some land trusts have begun to work proactively,

contacting landowners if they have particularly high value lands. This tool can be used in either fashion, through determining parcels of interest and pursuing them proactively, or simply as a reference if a landowner approaches the land trust with a potential conservation project.

Combined, land trusts like the NCCLT have protected millions of acres across the U.S. in perpetuity. Any tool that has the potential to assist this effort is thus extremely relevant. If altered according to the objectives of a specific land trust or conservation group, different versions of the Land Prioritization tool designed here could be used to help make transparent decisions in an efficient and effective manner in future land protection efforts.

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APPENDIX

Tool Description:

The major function of the NE North Carolina Land Prioritization tool is to examine conservation value of parcel level data through a rule based system. The tool (1) combines relevant conservation criteria into a summary table that displays the statistics for each criteria in each parcel; and (2) runs a user defined prioritization analysis based on this summary table. This tool was designed for northeastern North Carolina but may be used for more general use if data inputs are in the correct format. The tool examines the following indicators/criteria: total area, distance from managed lands, distance from SNHA, distance from land trust (in this case NCCLT) properties, distance from major and minor waterways, distance from roads, distance from urban areas, percent area covered by the 100 year floodplain, and percent area covered by wetlands (NC-CREWS). The tool is intended for use by someone with some GIS familiarity, but has step by step instructions here and embedded in the tool.

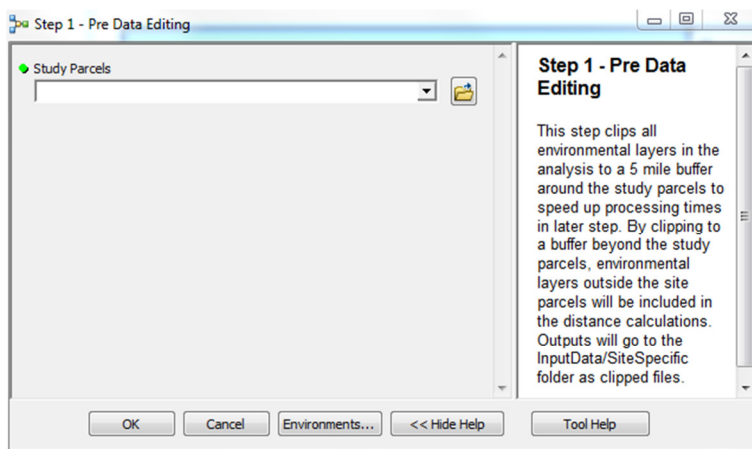
The basic workflow of the GIS prioritization tool requires 6 steps, run in order in the Land Prioritization Toolbox:

1. Pre-Data editing
2. Data Calculation
3. Utility Calculations
4. Calculate Criteria (a-e)
5. Calculate Final Weights
6. Join Output Tables

Tool Instructions:

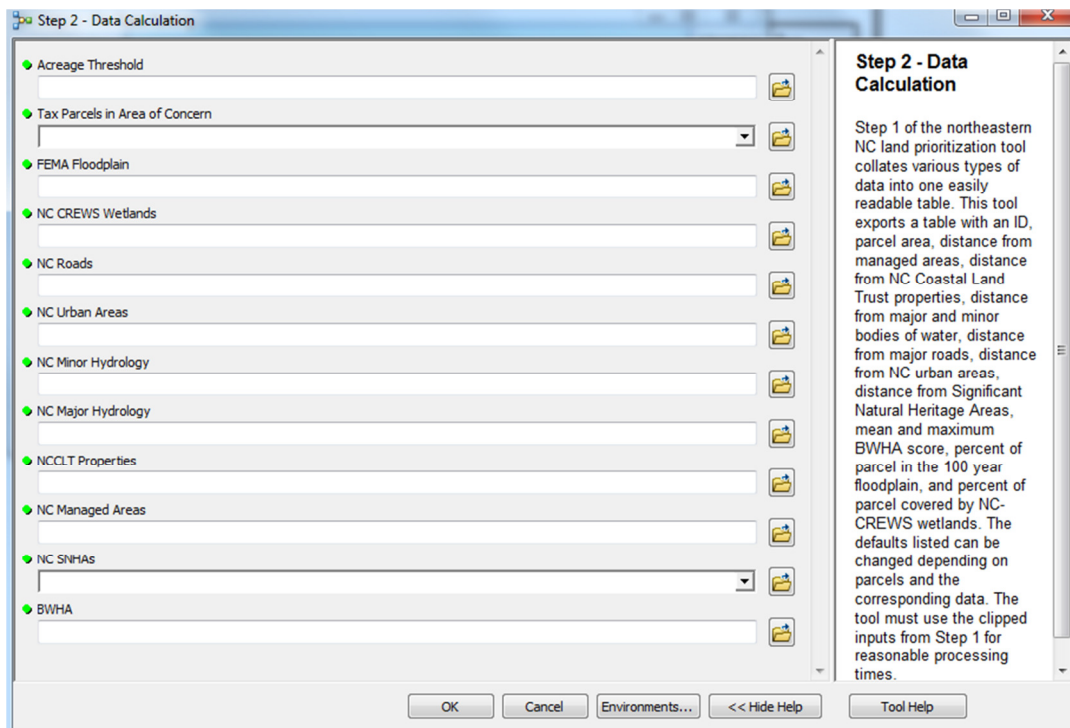
Step 1:

Select the study parcels you plan to use in your analysis. Put all environmental layers you plan to use in the Data folder in the workspace. North Carolina Data at the time of this article (2014) is already included in this folder. This step iterates through all the environmental layers and clips them to a buffered study area to speed later processing times.



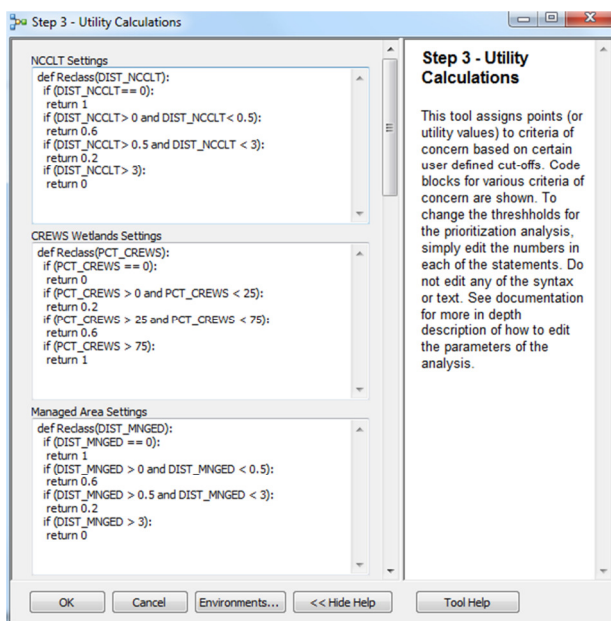
Step 2:

All data has now been clipped and is located in the “SiteSpecific” folder. Set the acreage threshold for which parcels to exclude from the analysis. Inputting “5” in this box, for example, would exclude all parcels less than 5 acres from the analysis. Next, input the clipped environmental data from the “SiteSpecific” folder in the corresponding dialog windows. For example, the clipped roads shapefile goes in the NC Roads box. Once all data is input, run the tool. This step creates a summary table of statistics for each of the indicators. Depending on the number of parcels, processing may take some time.



Step 3:

This step sets the utility value thresholds and points assigned to each class in the indicator. At first

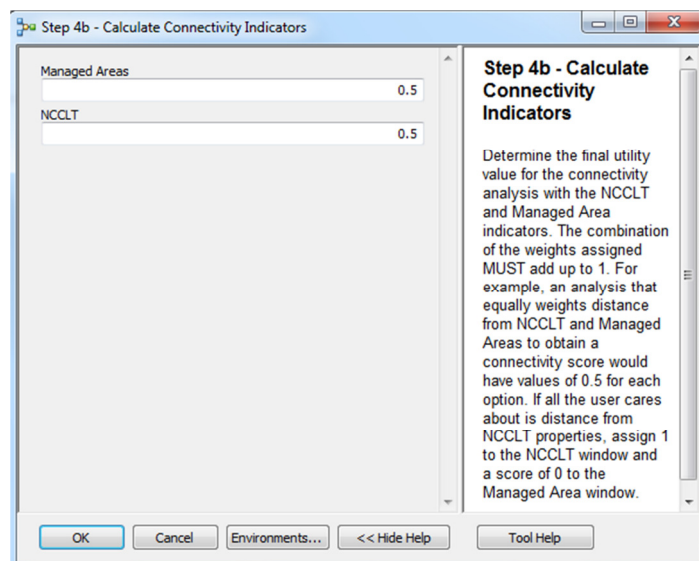


glance, the format for the inputs might seem difficult to understand, however, this method provides maximum flexibility in setting values if instructions are followed carefully. It also allows advanced users to more quickly made additions to the thresholds as desired. As a trade-off, user error that disrupts functioning of the tool is possible in this step if the user is not careful. A series of if-then statements are shown that return certain point values. Do not change the text, spacing, or symbols. Only change the numbers in the if-then statement. For example, in the snapshot shown here:

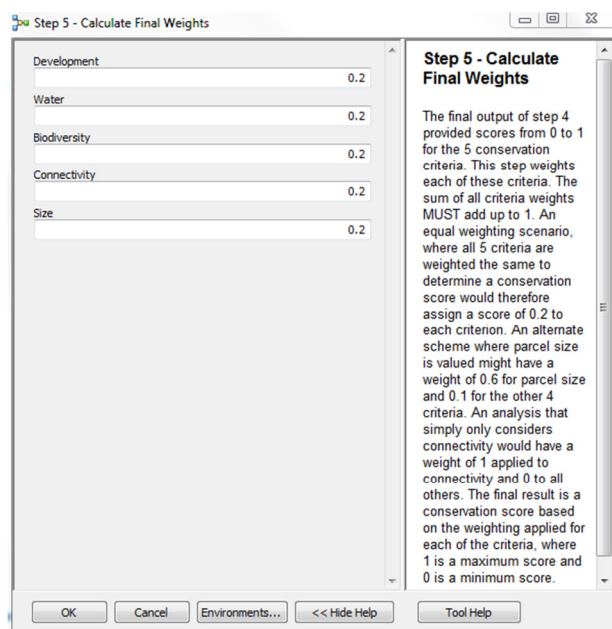
The first code is stating, if the parcel is located within 0 miles (adjacent) to a NCCLT property, give it a point value of 1. If the parcel is between 0 and 0.5 miles, assign it a point value of 0.6. If the parcel is between 0.5 to 3 miles away from the NCCLT property, assign it a point value of 0.2. Finally if the parcel is greater than 3 miles away, assign the parcel 0 points. The user can change the points assigned by changed the number following “return.” The user can change the criteria cut-offs by changing the number in the “if” part of the statement. Remember, do not change the words in the text, which are connected to the table fields. Only change the numbers, keeping the format the same. After this step, all indicators will have utility values assigned to them.

Step 4:

Step 4 is divided into 5 parts, (a) to (e), for each criteria. This step assigns the weights of the indicators for each of the criteria. Simply click and run each model in order. The user can define the weights of the indicators, with the one caveat that the sum of the indicators must add to 1.0. For example, connectivity indicators could be 0.5 and 0.5, 0.75 and 0.25, 0.9 and 0.1, or any other combination that sums to 1.0.



Step 5:



This step weights each of the criteria to calculate a final conservation score. Again, the only restriction is the weights must add to 1.0.

Step 6:

The final step simply joins and outputs the final products of the tool. After running all steps, the user should have in the “Data/FinalOutputs” folder 4 files.

- a.** Summary Table with the calculated data for each criteria and the points from the prioritization analysis
- b.** Full Results Table with all summary statistics, indicator points, criteria scores, and final conservation value
- c.** Summary Points Table with only the ID and points from the prioritization analysis
- d.** A shapefile (Final_Parcel) joined with the original tax information that can be used in ArcMap to map the prioritization analysis.